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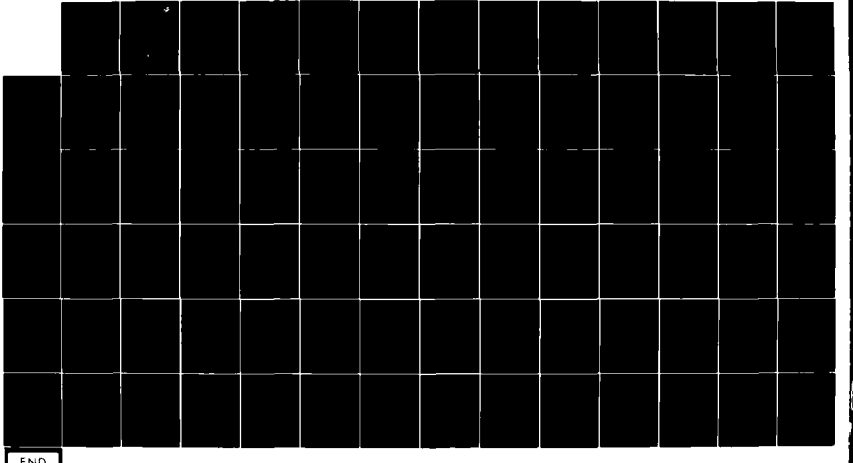

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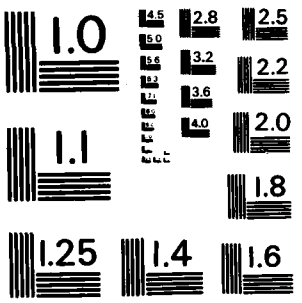

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NRL Memorandum Report 5168

Computed Survey Spectra of 2-5μ Atmospheric Absorption

D. H. LESLIE AND P. S. LEBOW

Applied Optics Branch
Optical Sciences Division

August 31, 1983

NAVAL RESEARCH LABORATORY
Washington, D.C.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Computed high resolution survey spectra of atmospheric absorption coefficient vs wavenumber are presented covering the wavelength region 2-5 μm. The 1980 AFGL atmospheric absorption parameter compilation was employed with a mid-latitude, sea-level atmospheric model.

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COMPUTED SURVEY SPECTRA OF 2-5μ ATMOSPHERIC ABSORPTION

This report presents computed spectra of atmospheric absorption in the 2-5 μm region. The spectra collected here followed from a request for detailed information on narrow transmission windows. The recent availability of tunable laser sources at 2-5 μm, including *F*-center lasers and downshifted Raman devices, has renewed interest in narrow atmospheric transmission windows.

The spectra in Figs. 3-77 present molecular absorption coefficient (km^{-1}) vs wavenumber (cm^{-1}), where $\nu(cm^{-1}) = 10^4 \times \lambda^{-1}(\mu m)$. Aerosol scattering and absorption are not considered here. The standard midlatitude-summer sea-level atmosphere is assumed, and described in Table 1. The water vapor standard isotopic ratio $HDO/H_2O = 0.030\%$ is assumed.

Table 1 — MidLatitude Summer Sea-Level Atmospheric Parameters

Molecular	Pressure (torr)	Concentration (ppm)
H_2O	14.26	1.88×10^4
CO_2	0.251	330
O_3	2.3×10^{-5}	0.030
N_2O	2.1×10^{-4}	0.276
CO	5.7×10^{-5}	0.075
CH_4	1.2×10^{-3}	1.58
O_2	159.6	2.10×10^5
N_2	585.9	7.7×10^5

NOTE: Temperature = 22.9°C

The calculations were performed using our HITRAN code with the 1980 AFGL line compilation.[1,2] The plots were made on a Versatek plotter at 100 points per inch resolution. Since each plot is 40 cm^{-1} long across 7 inches, the effective wavenumber resolution is approximately 0.057 cm^{-1} per point. At sea level almost all absorption lines are pressure broadened to a HWHM greater than 0.05 cm^{-1}. The plot parameters were chosen to maximize the number of wavenumbers per plot panel, without undersampling the true spectrum. The user of these survey spectra is cautioned to pay atten-

tion to the vertical scale; each panel is self-scaling so some plots cover 2 decades where others cover as much as 6 decades of absorption coefficient.

The 1982 AFGL listing has recently been released,[3] but no significant changes have been made in the 2-5 μm region for the molecules considered here. Areas of uncertainty remain in the specific correction needed for the sub-Lorentz CO_2 lineshape,[4,5] and the Burch[6] vs White[7] 3.3-4.2 μm water continuum absorption model.

Table 2 — Spectral Plot Parameters

Lineshape: Lorentz with ± 20 cm^{-1} bound Self-to-Foreign Broadening: [1]		
	Ratio: γ_s/γ_F	Temperature Coefficient $\gamma \sim T^n$
H_2O	5.0	0.62
CO_2	1.3	0.58
O_3	1.0	0.50
N_2O	1.24	0.50
CO	1.02	0.50
CH_4	1.3	0.50
O_2	1.0	0.50

NOTE: Water Vapor Continuum 2350 – 2800 cm^{-1} [5,6]
Nitrogen continuum 2080 – 2740 cm^{-1} [5,8]
CO_2 sub-Lorentz lineshape [4]

The spectral plot parameters are summarized in Table 2. The two continuum absorption contributions are well documented in the literature. The line-by-line summation was carried out to ± 20 cm^{-1} from the plotted frequency. The correction to the CO_2 spectra to account for the sub-Lorentz line shape is described in Fig. 1 and Eq. (1) below:

$$k(\nu_0) = \chi(\nu - \nu_0)\, k_L(\nu_0) \tag{1}$$

where

$$k_L(\nu_0) = \frac{1}{\pi} \frac{\gamma S}{(\nu - \nu_0)^2 + \gamma^2}$$

and $\chi(\nu - \nu_0)$ is given in Fig. 1.

A broad-band transmittance plot for a 1 km path was produced using LOWTRAN-5b with the above atmosphere and no aerosols (9). This is given in Fig. 2 and is useful for a quick glance at the

same region covered by the 75 high-resolution absorbance plots. The effective spectral resolution of Fig. 2 is 20 cm^{-1}.

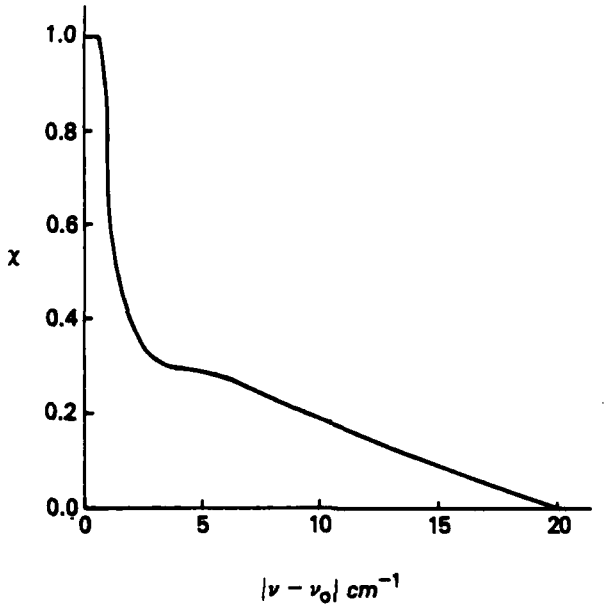

Fig. 1 — χ function in Eq. (1) used for CO_2 sub-Lorentz lineshape

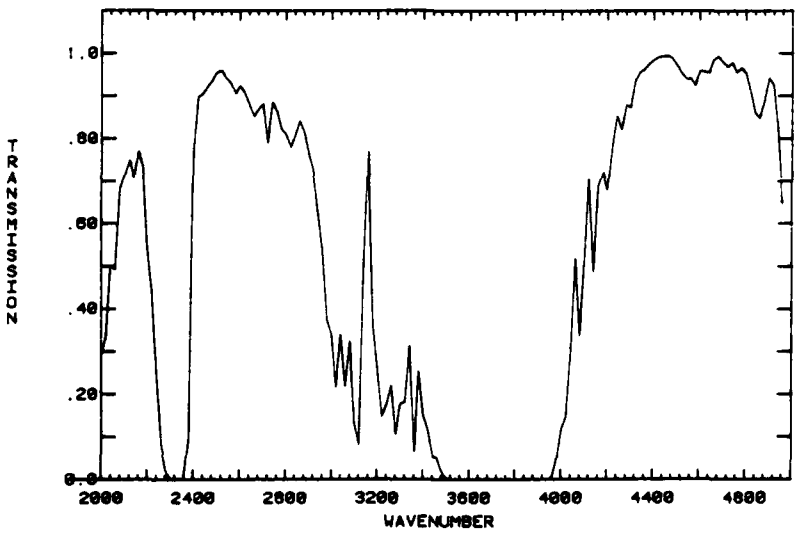

Fig. 2 — LOWTRAN-5 1 km mid-latitude summer sea-level transmittance 5-2 μm

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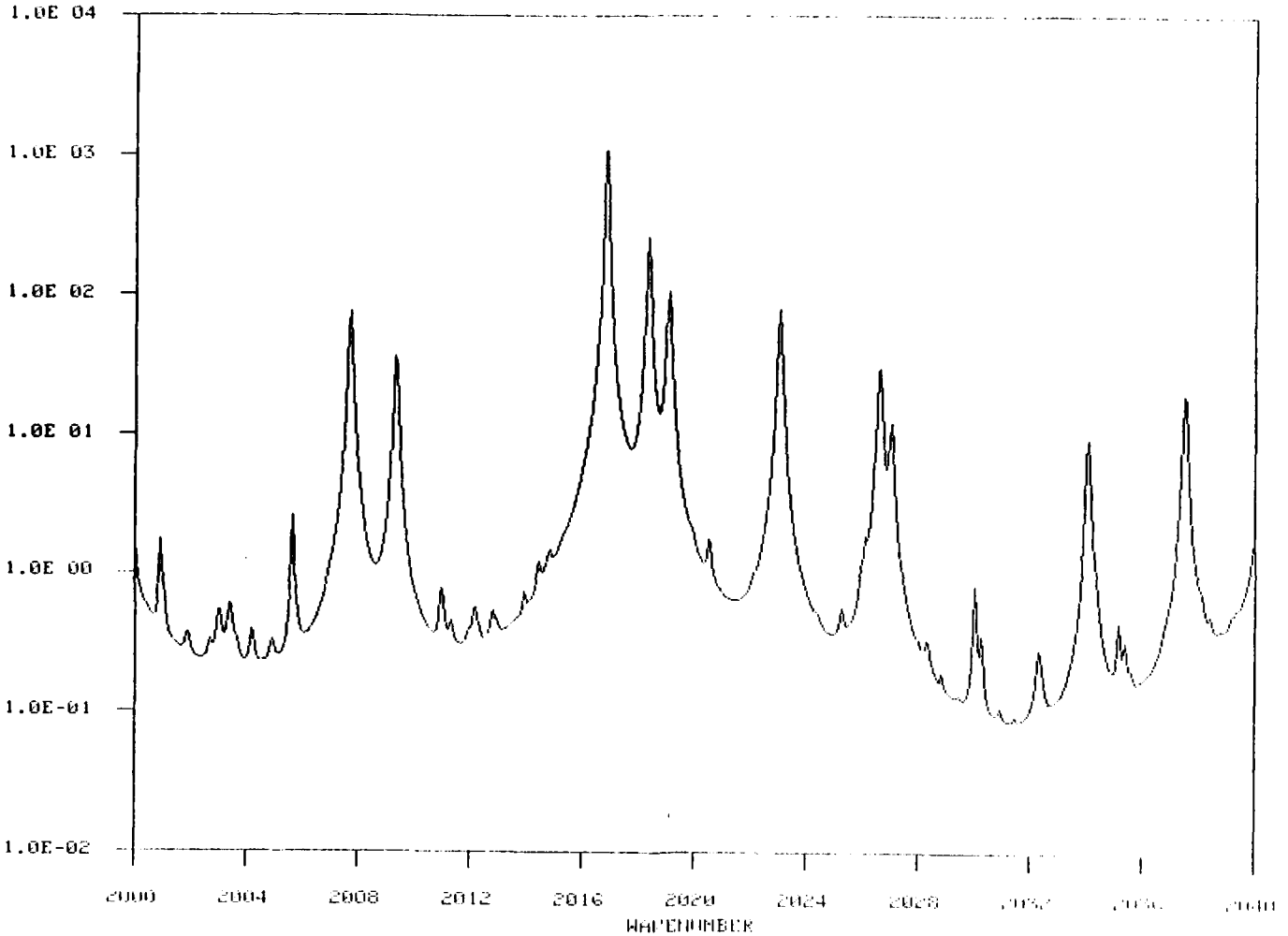

Fig. 3 — 2000-2040 cm^{-1} atmospheric absorption coefficient (km^{-1})

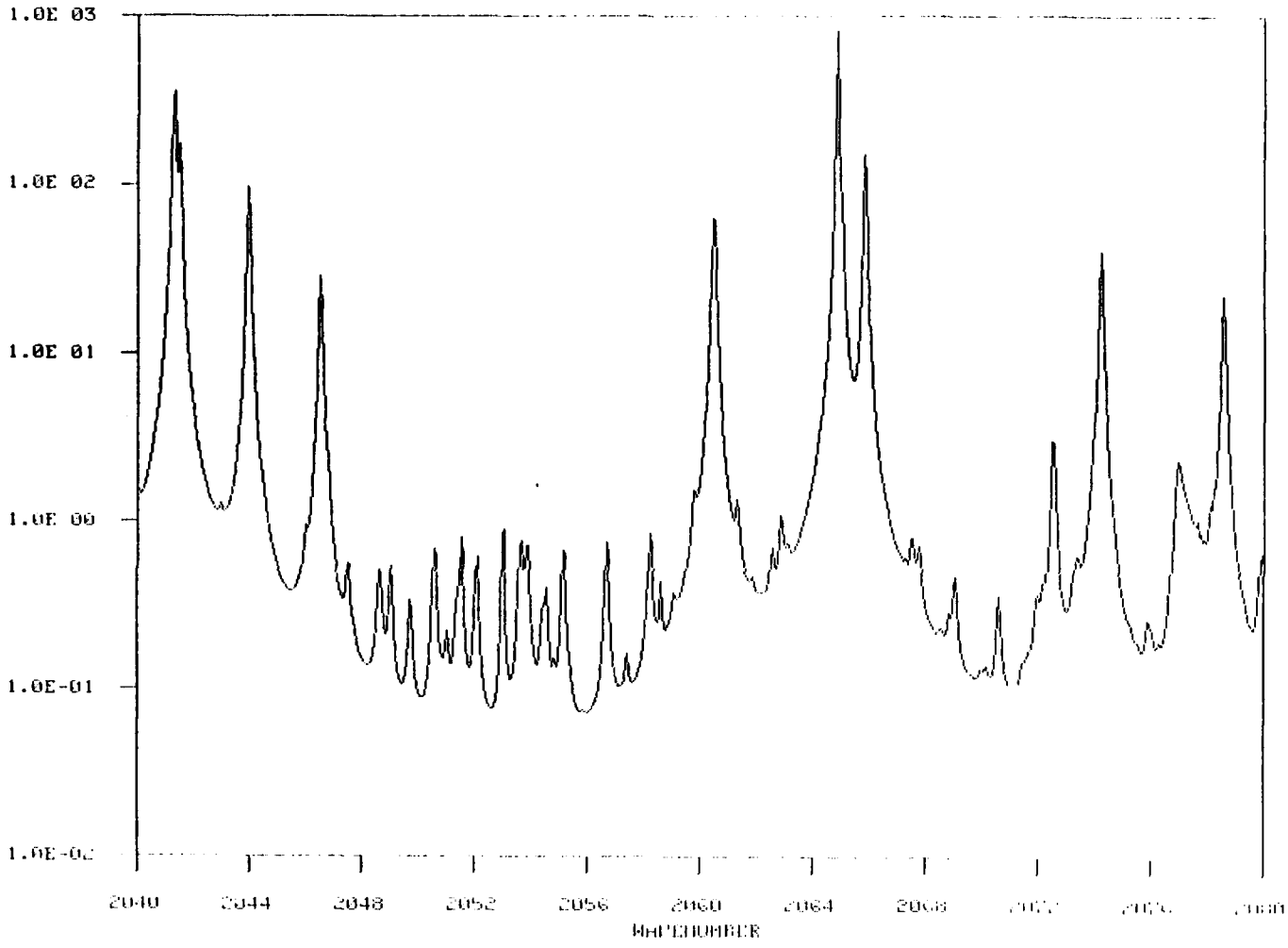

Fig. 4 — 2040-2080 cm^{-1} atmospheric absorption coefficient (km^{-1})

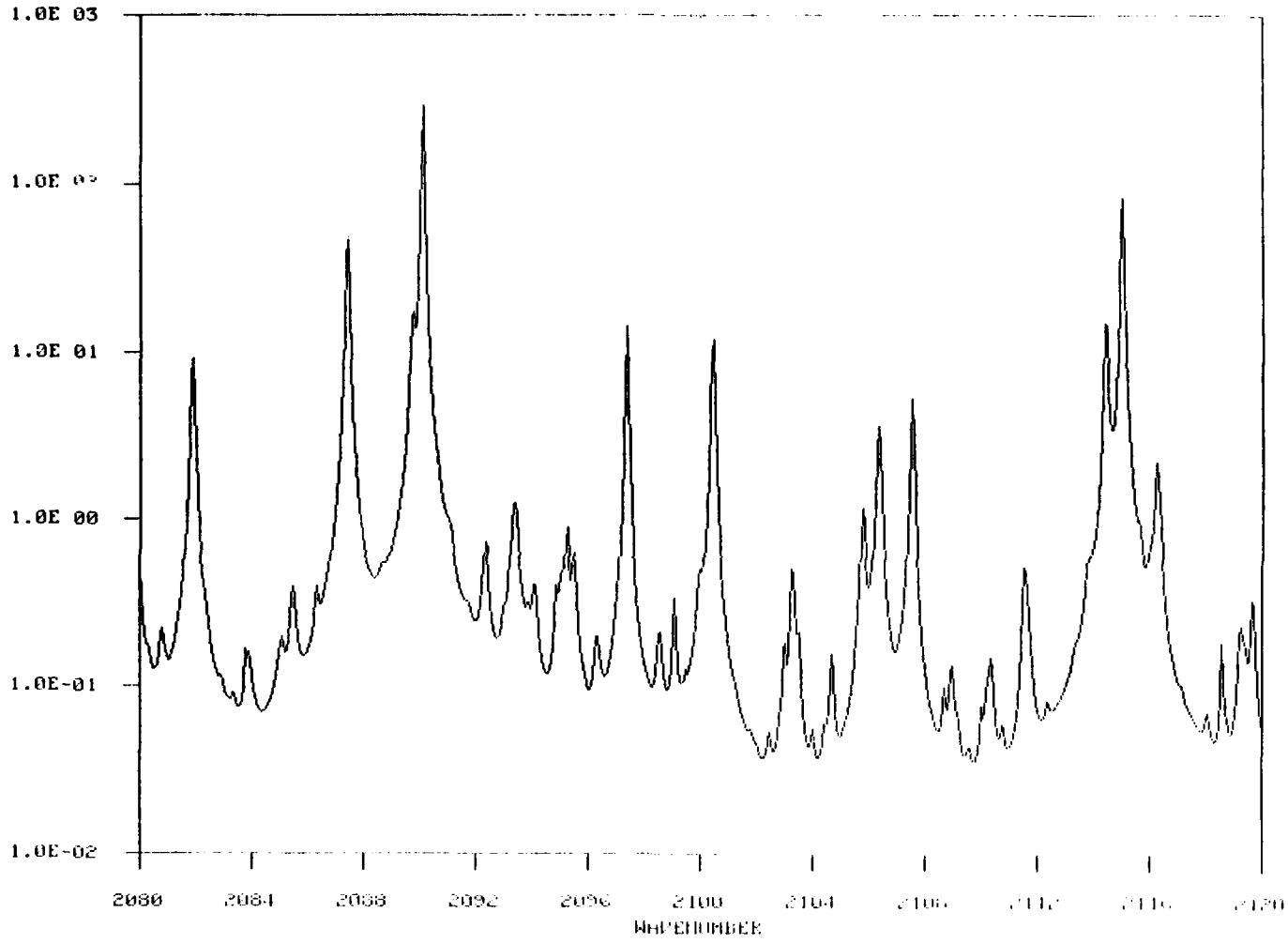

Fig. 5 — 2080-2120 cm^{-1} atmospheric absorption coefficient (km^{-1})

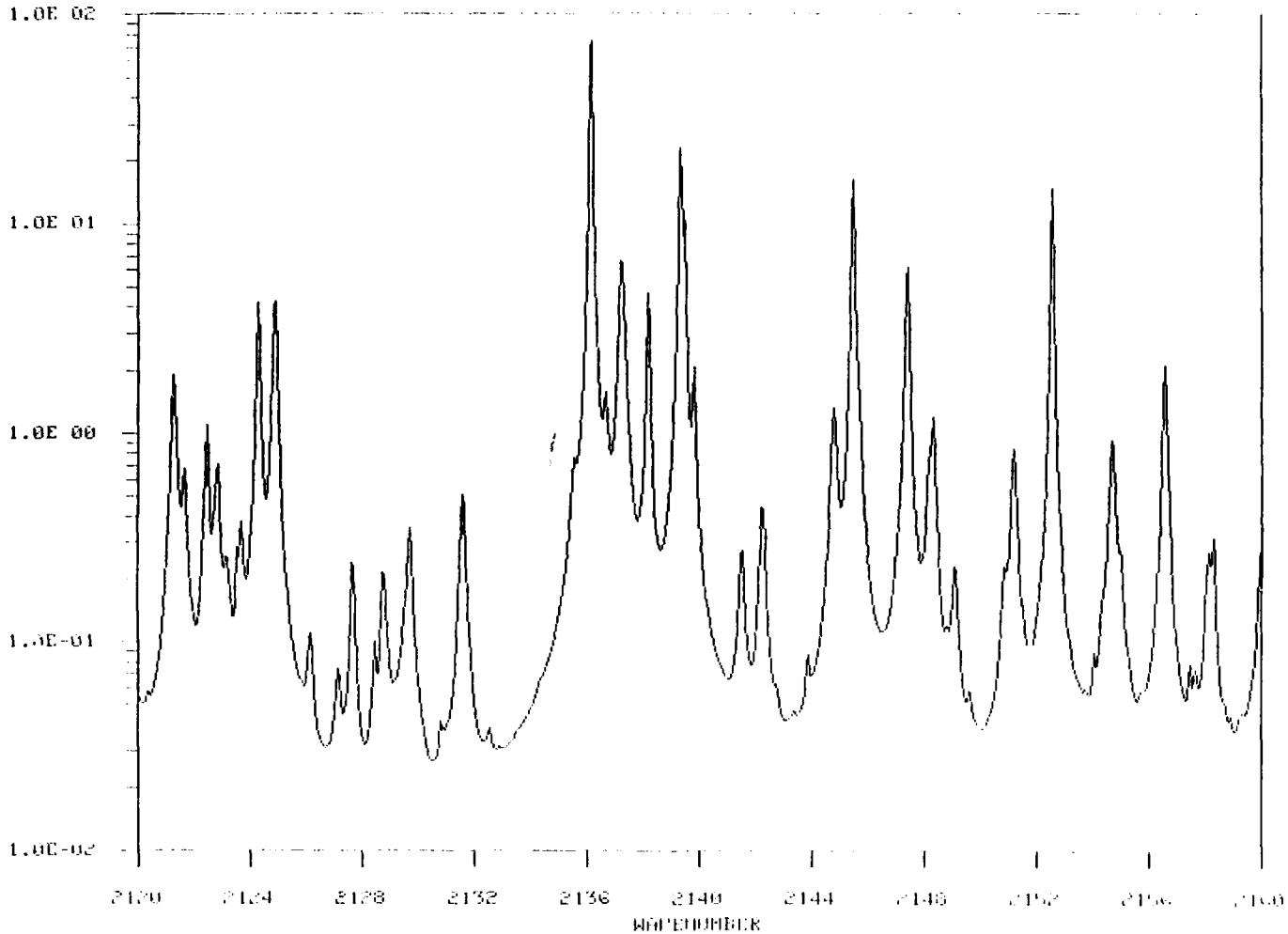

Fig. 6 — 2120-2160 cm^{-1} atmospheric absorption coefficient (km^{-1})

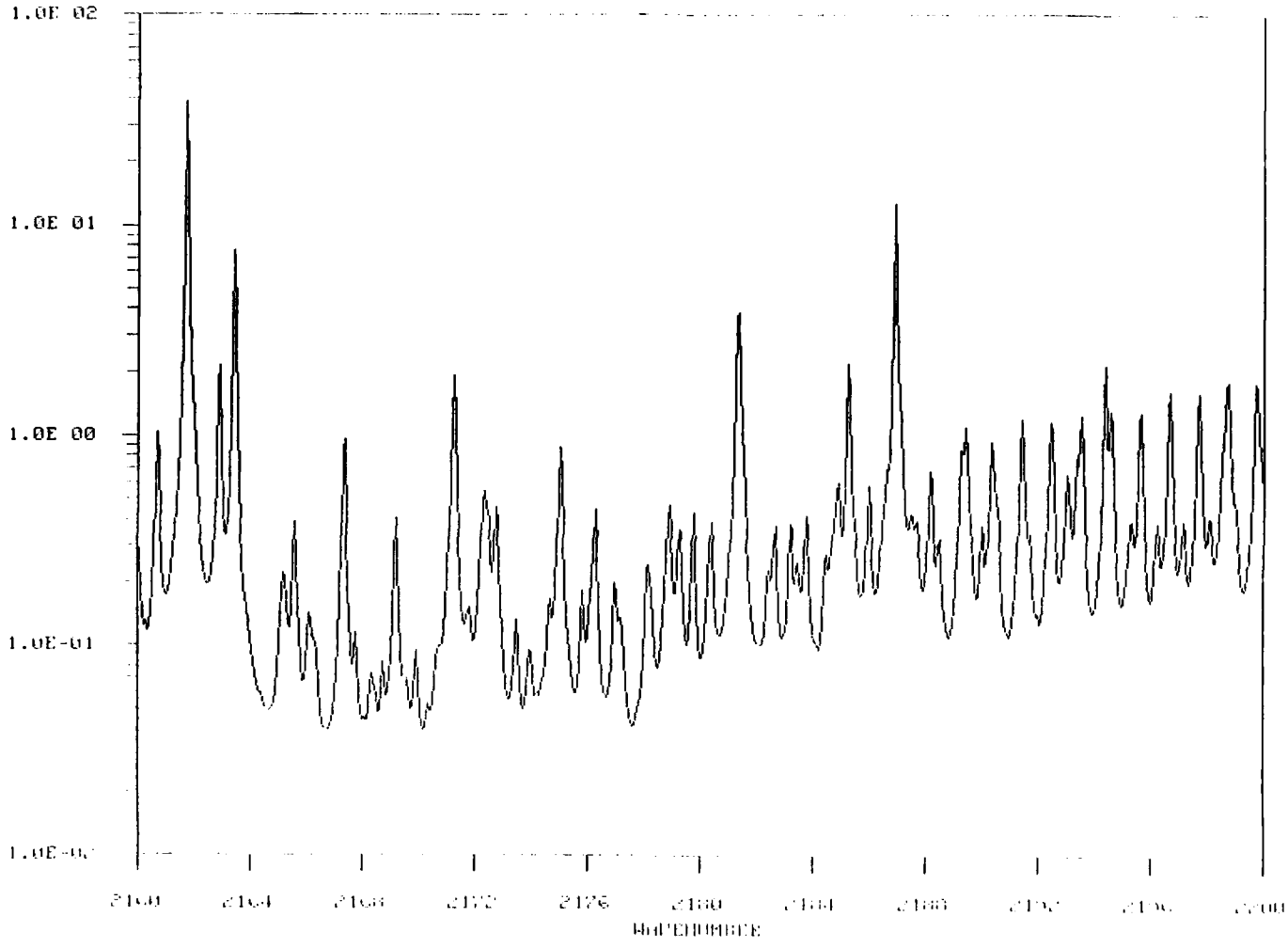

Fig. 7 — 2160-2200 cm^{-1} atmospheric absorption coefficient (km^{-1})

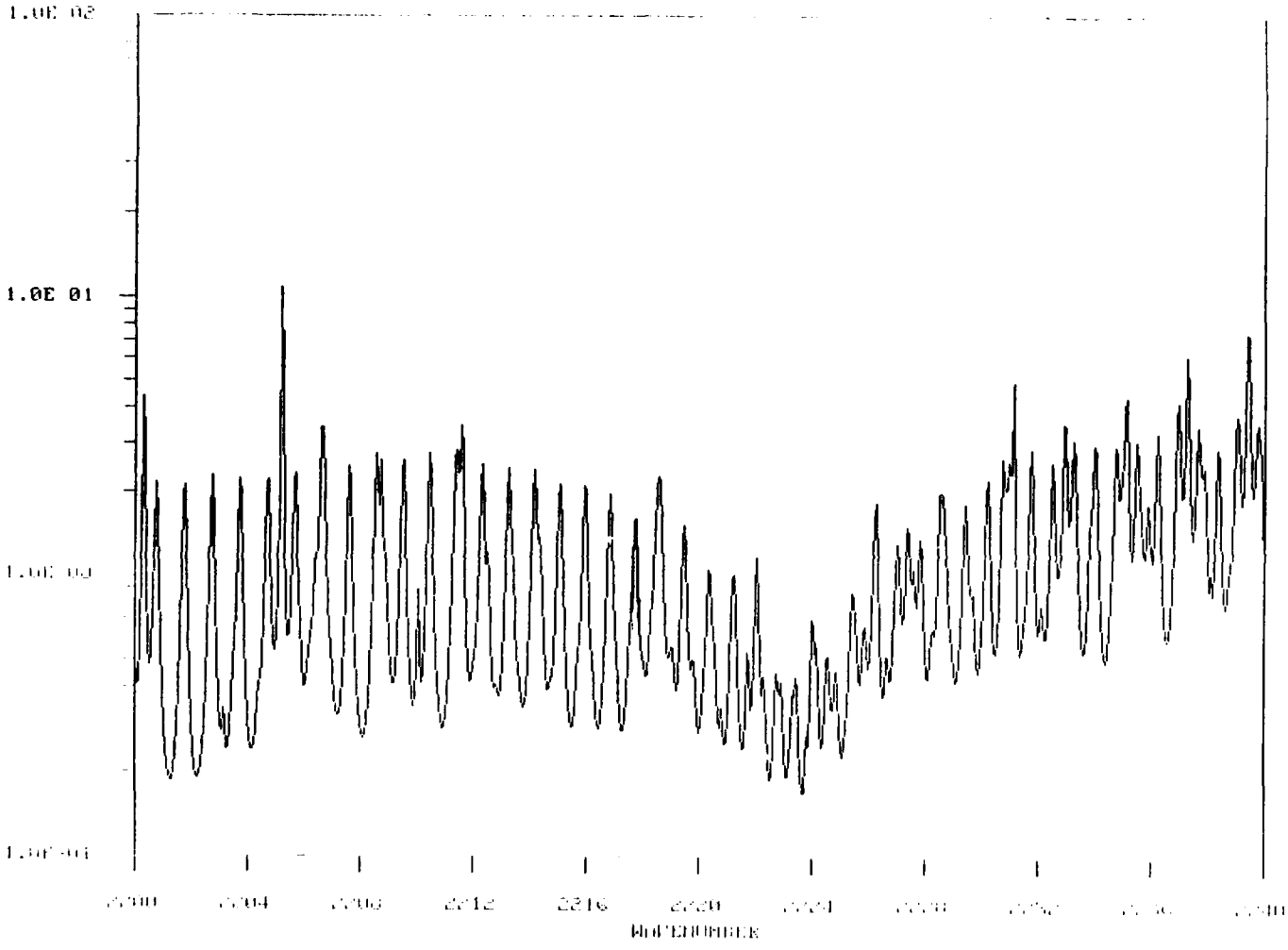

Fig. 8 — 2200-2240 cm^{-1} atmospheric absorption coefficient (km^{-1})

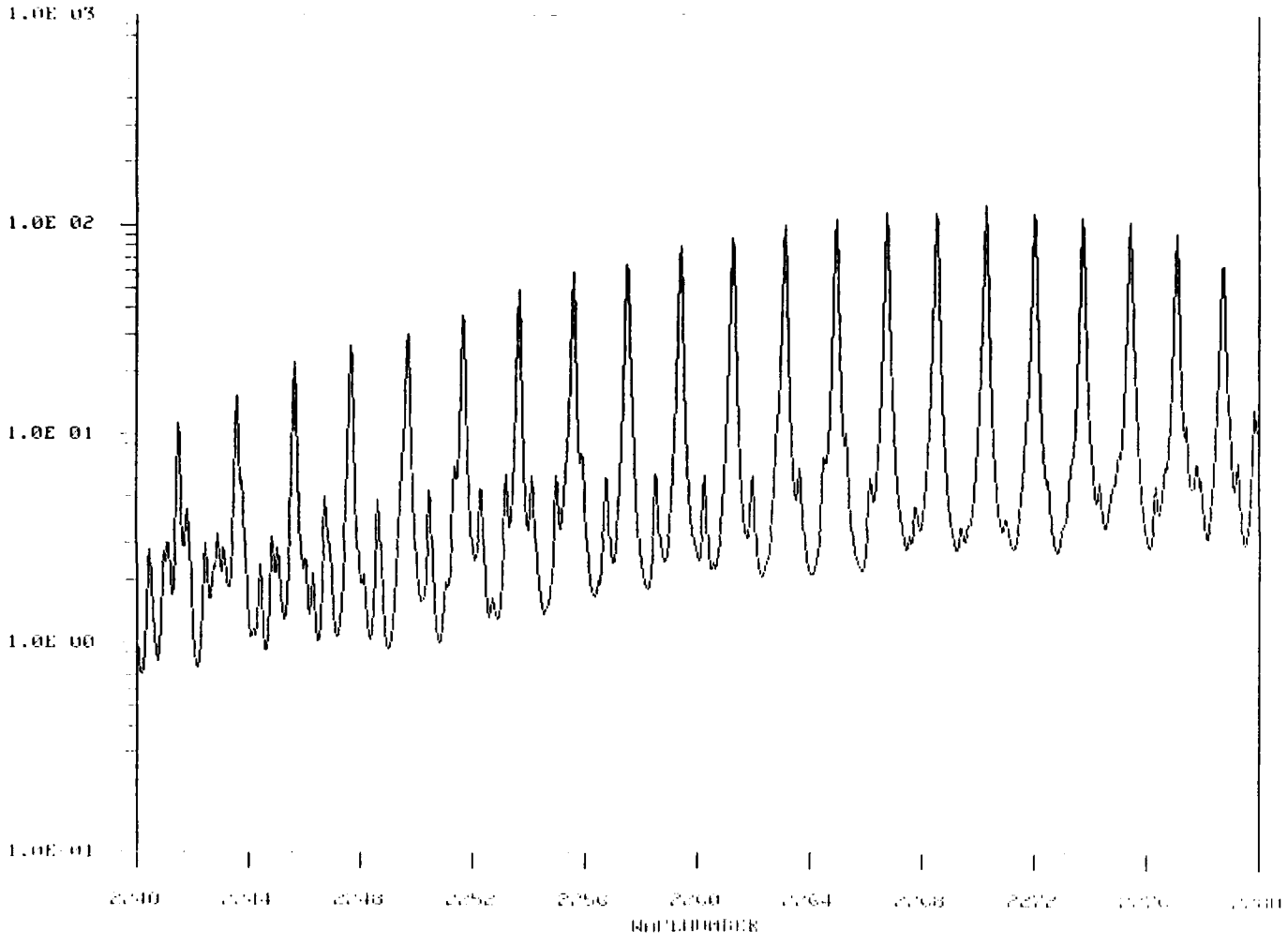

Fig. 9 — 2240-2280 cm^{-1} atmospheric absorption coefficient (km^{-1})

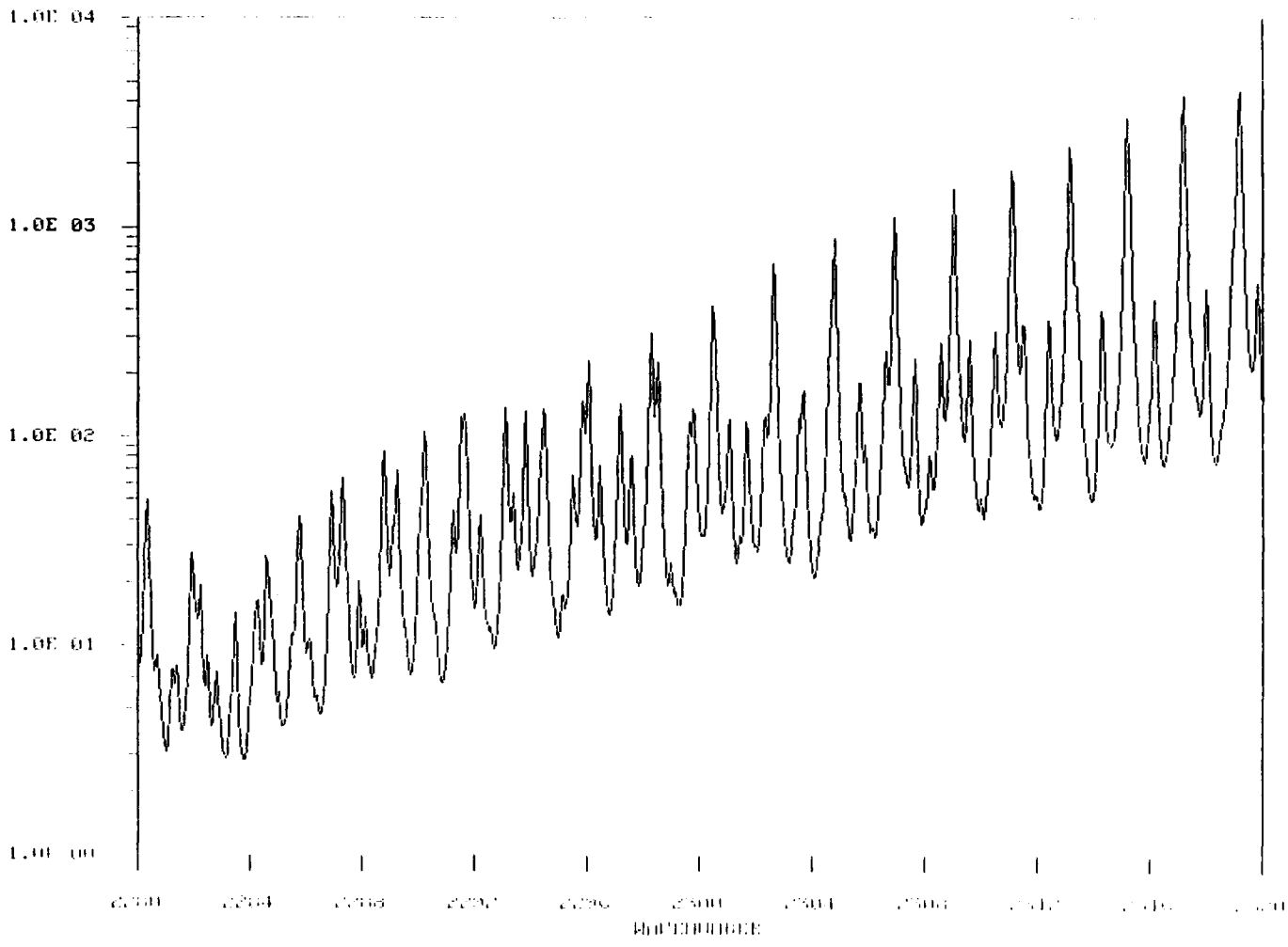

Fig. 10 — 2280-2320 cm^{-1} atmospheric absorption coefficient (km^{-1})

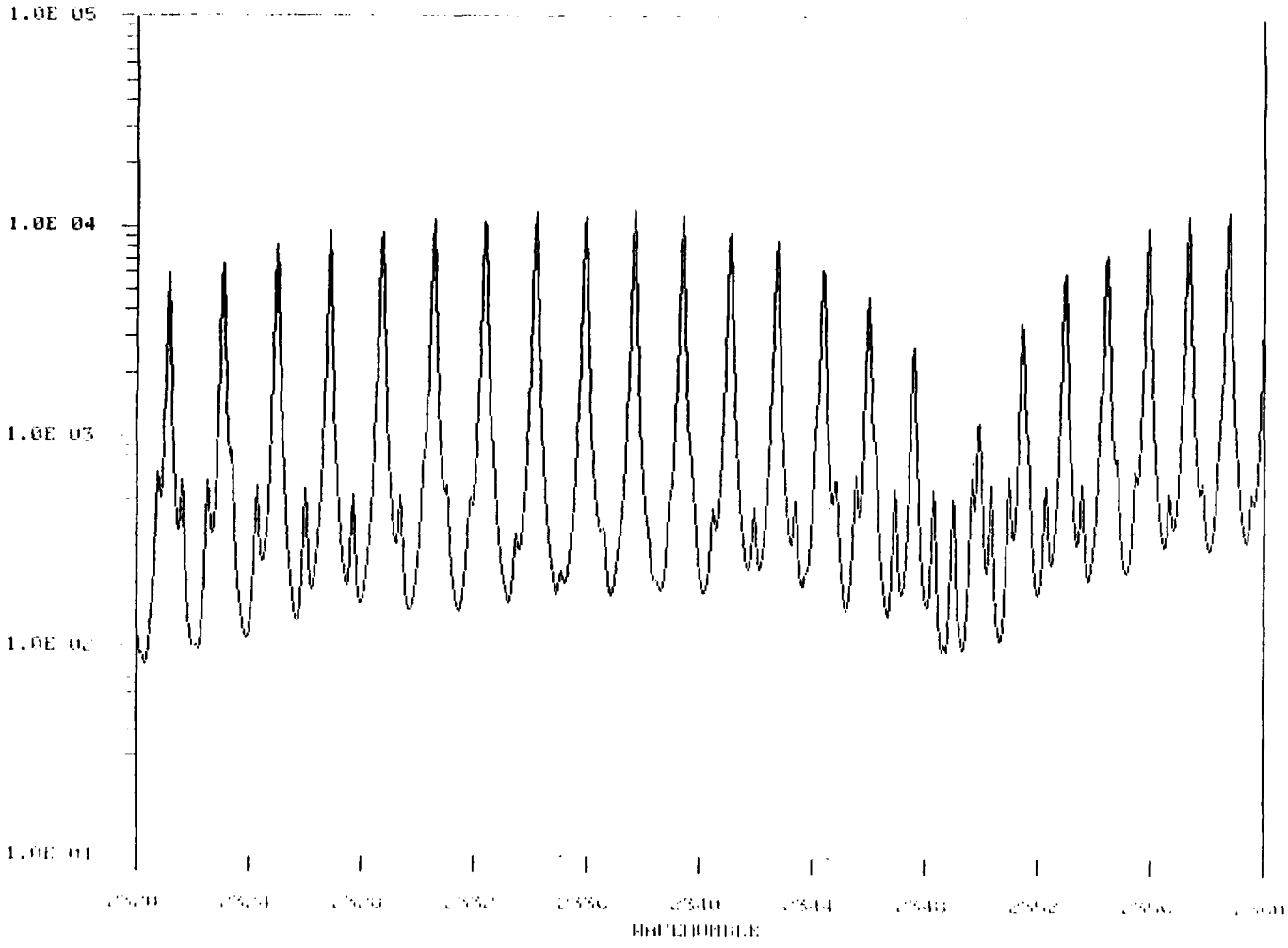

Fig. 11 — 2320-2360 cm^{-1} atmospheric absorption coefficient (km^{-1})

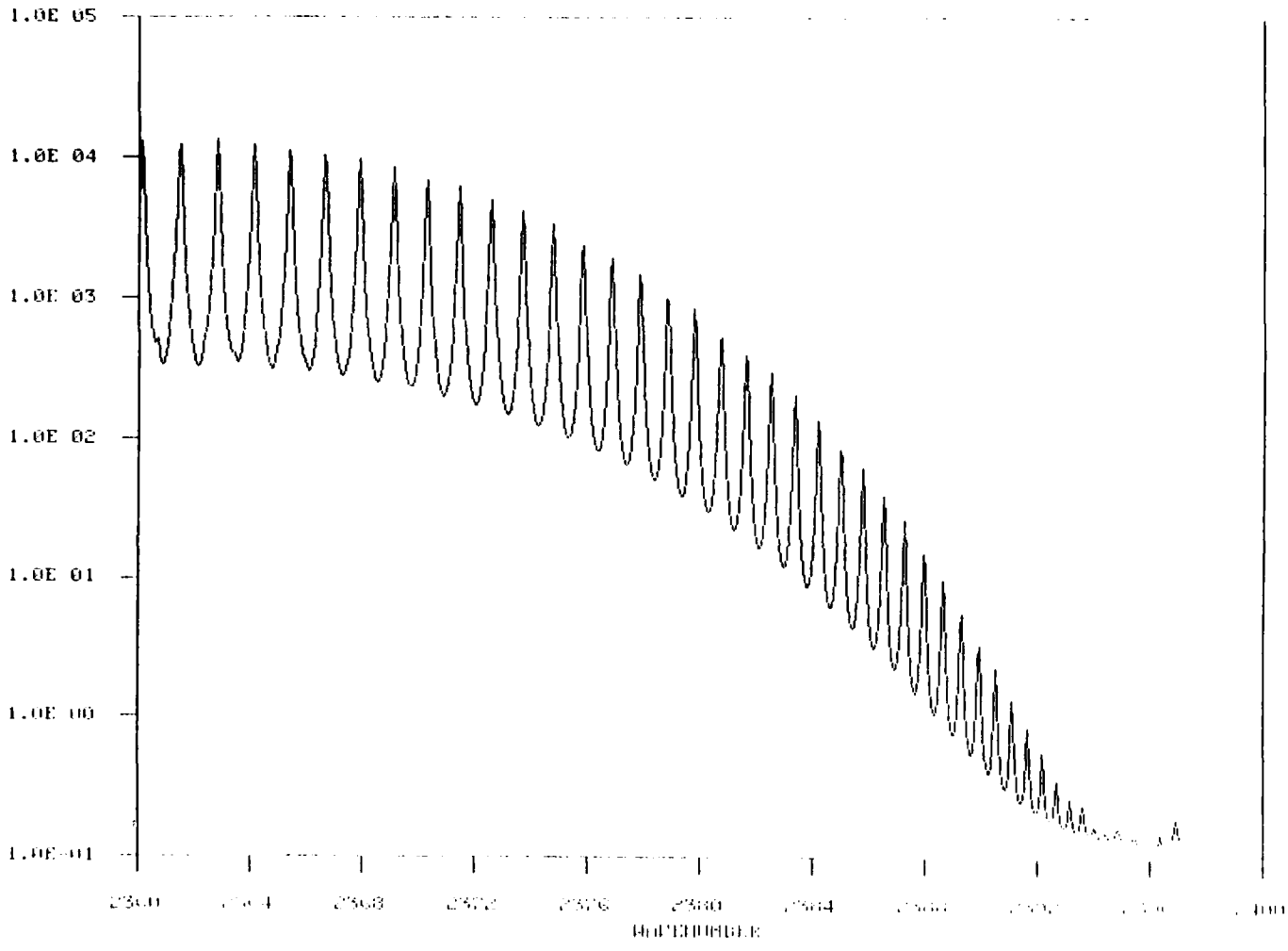

Fig. 12 — 2360-2400 cm^{-1} atmospheric absorption coefficient (km^{-1})

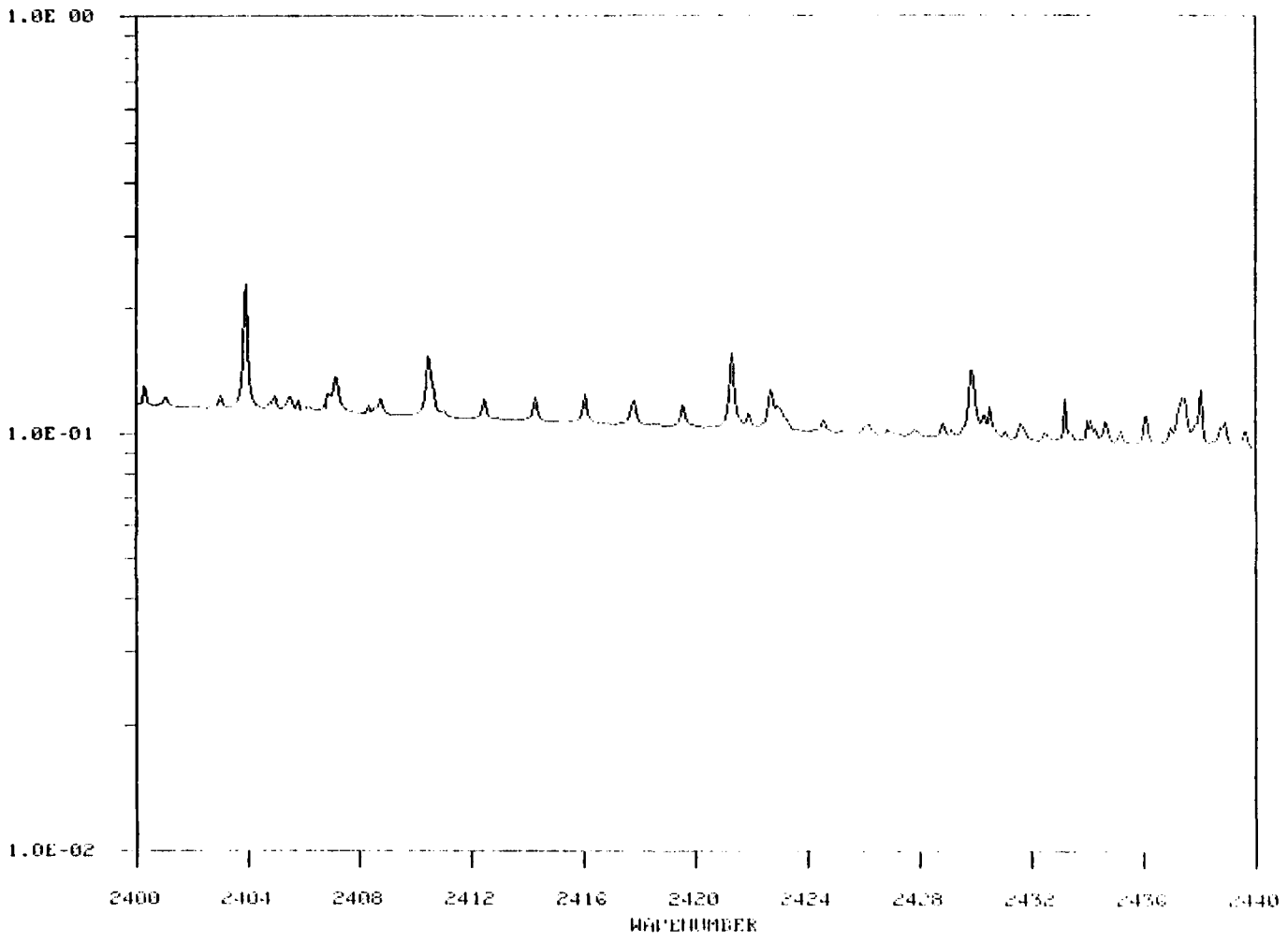

Fig. 13 — 2400-2440 cm^{-1} atmospheric absorption coefficient (km^{-1})

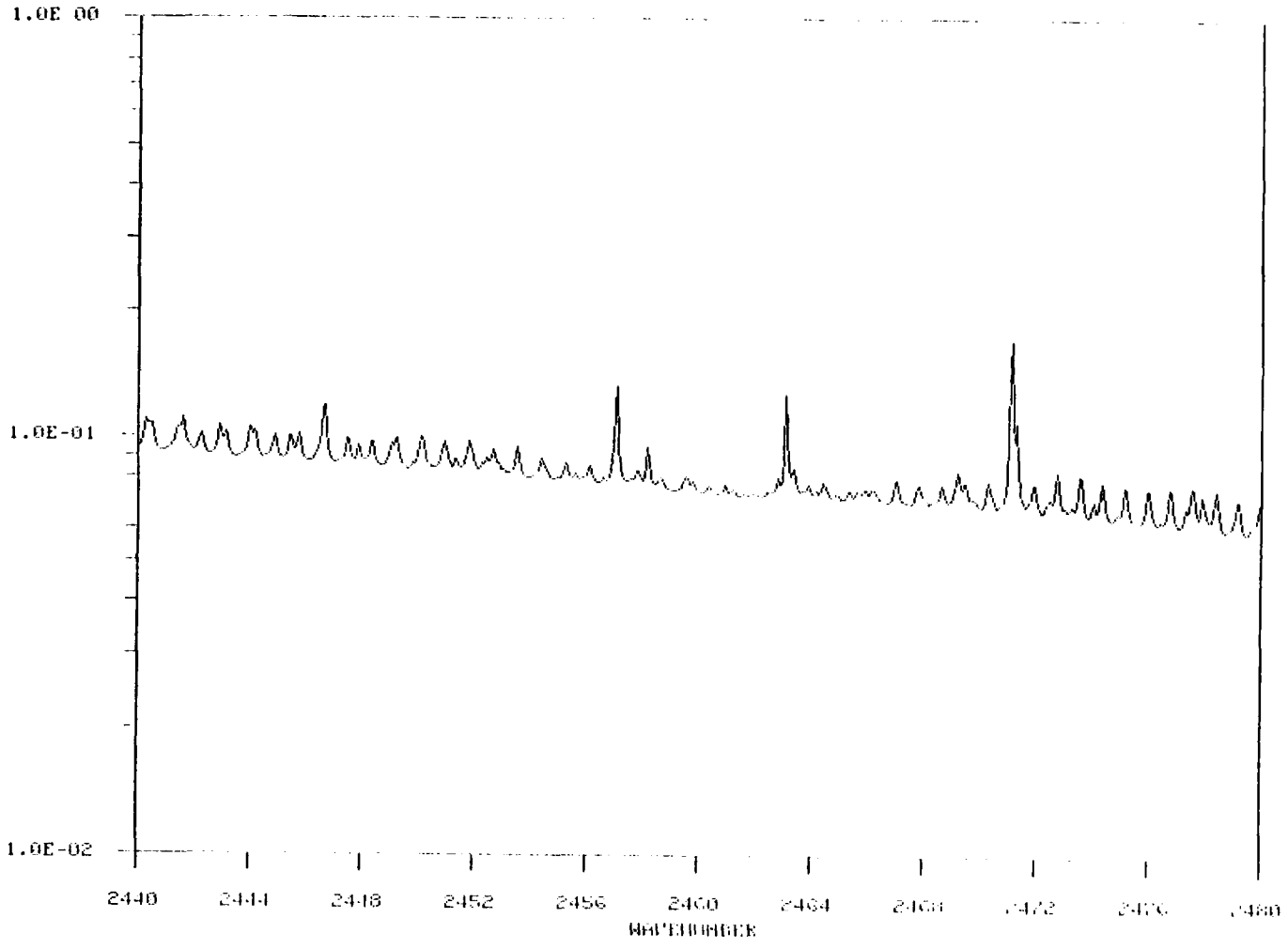

Fig. 14 — 2440-2480 cm^{-1} atmospheric absorption coefficient (km^{-1})

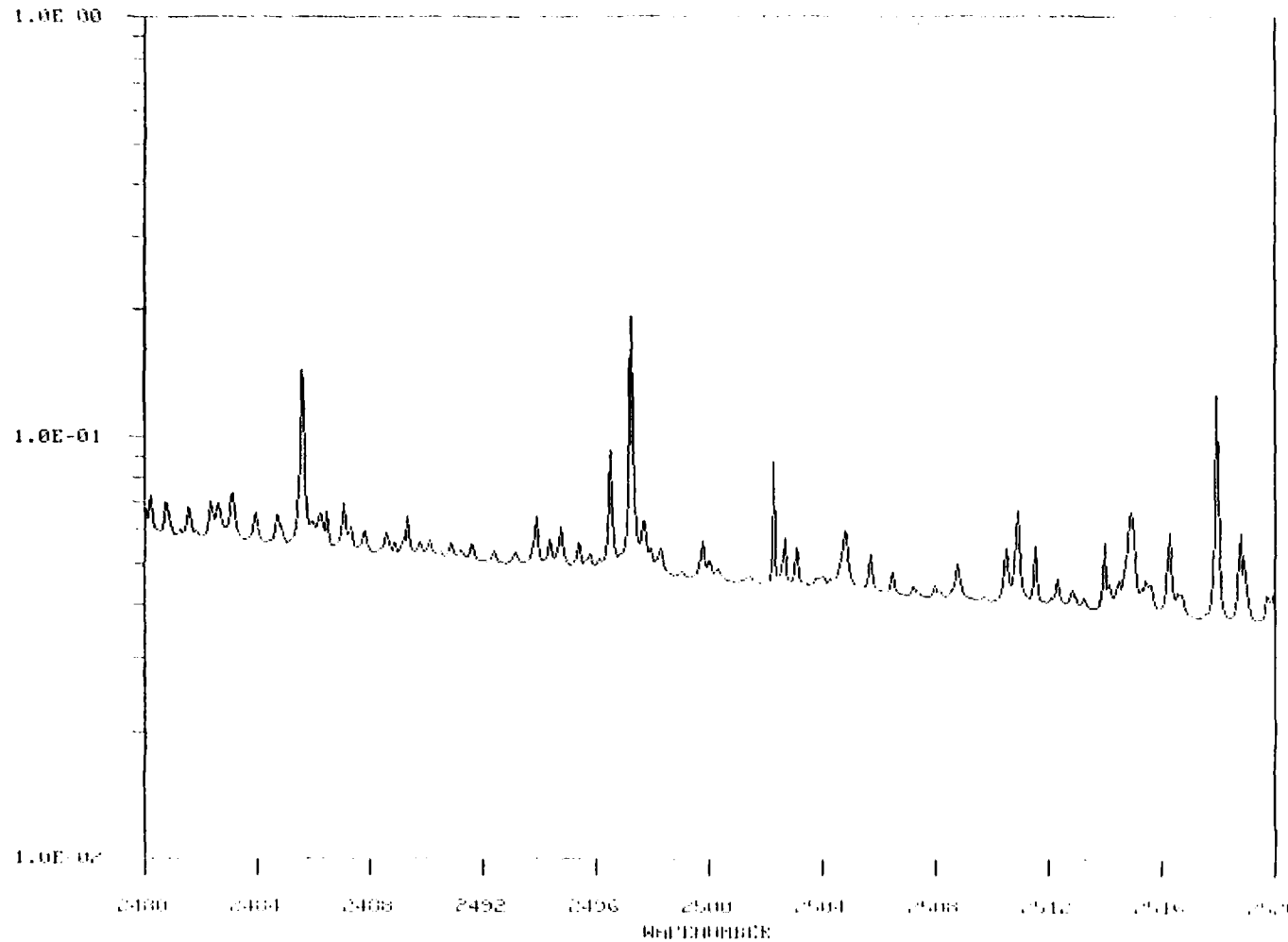

Fig. 15 — 2480-2520 cm^{-1} atmospheric absorption coefficient (km^{-1})

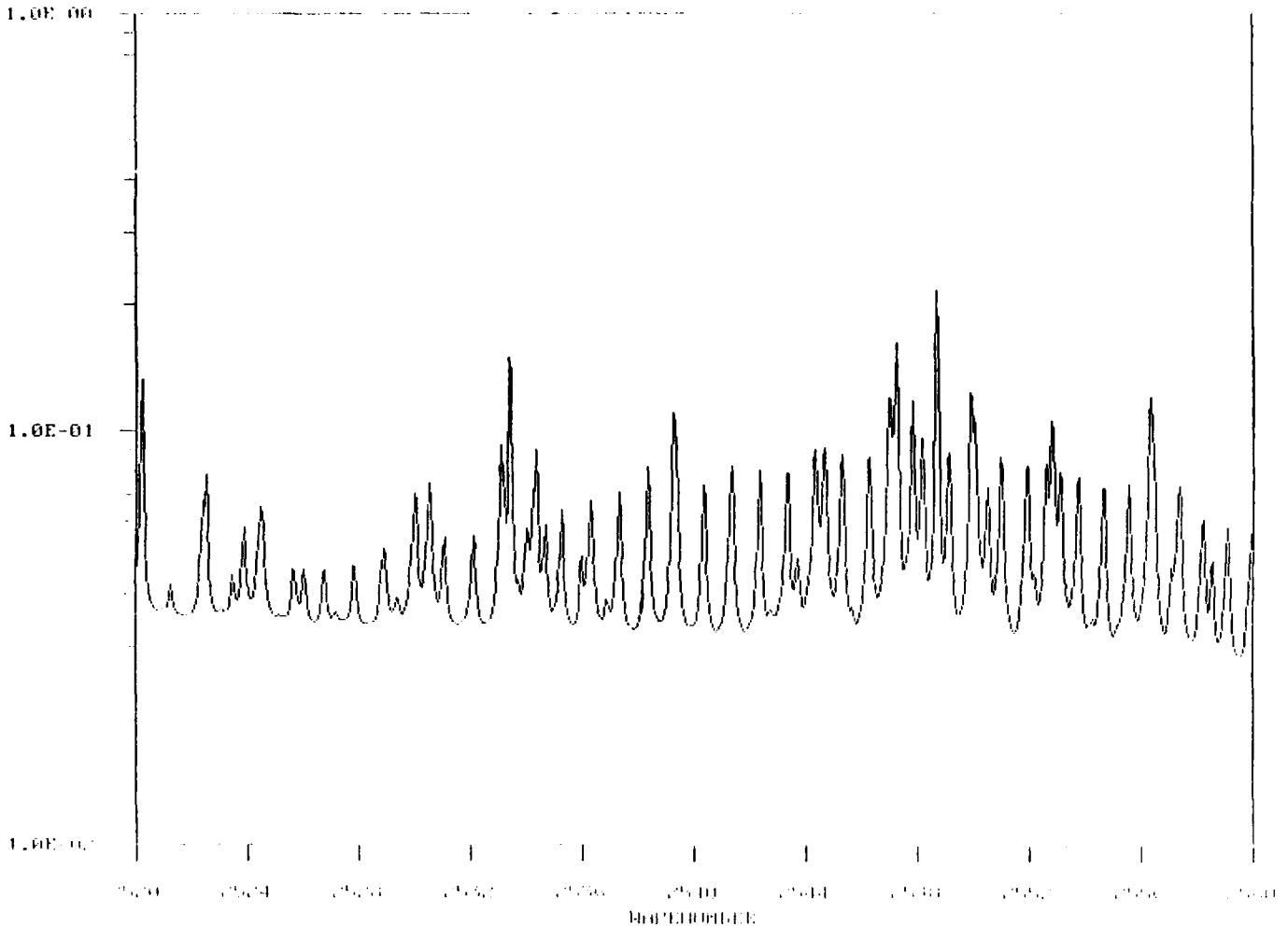

Fig. 16 — 2520-2560 cm^{-1} atmospheric absorption coefficient (km^{-1})

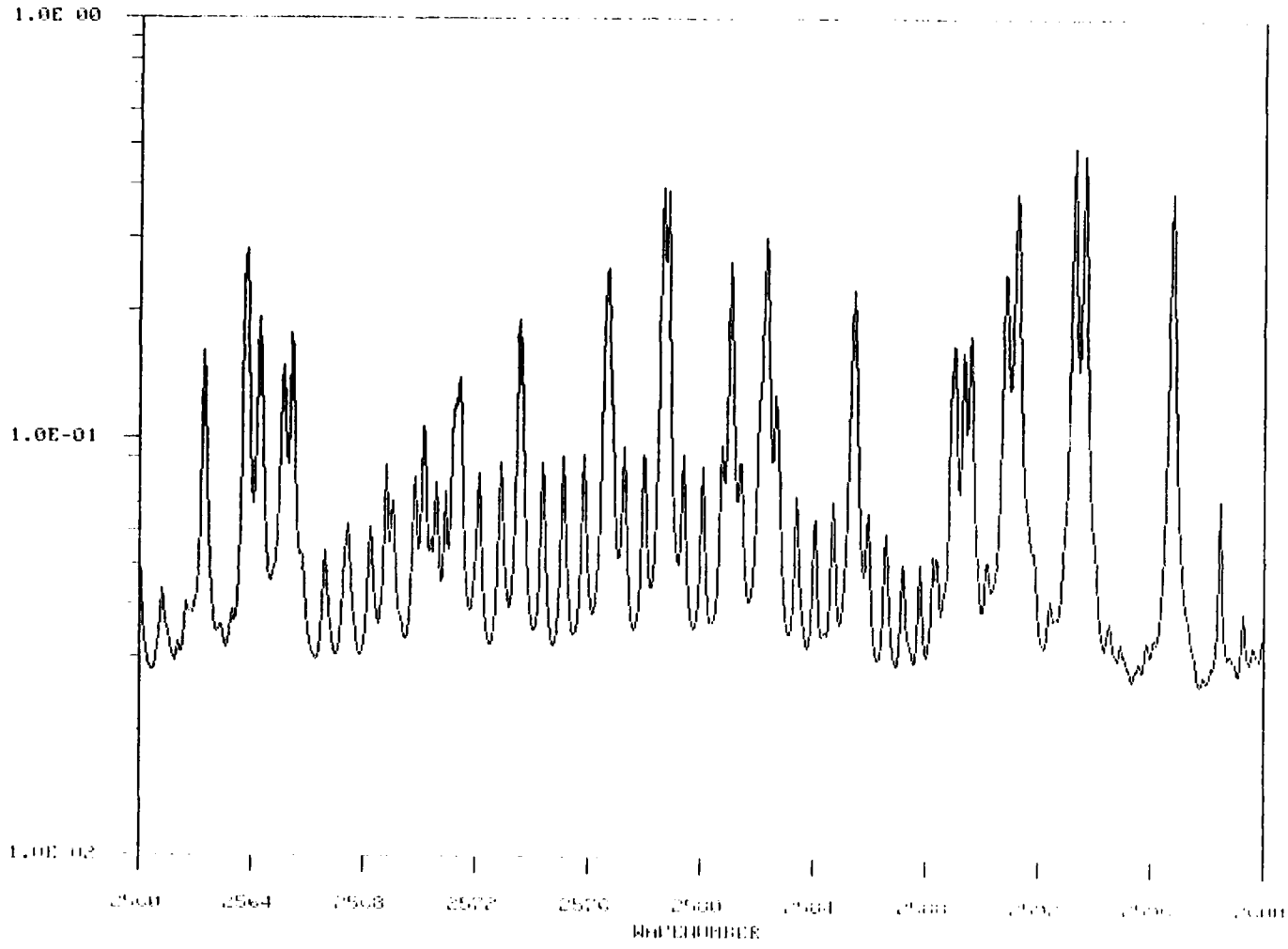

Fig. 17 — 2560-2600 cm^{-1} atmospheric absorption coefficient (km^{-1})

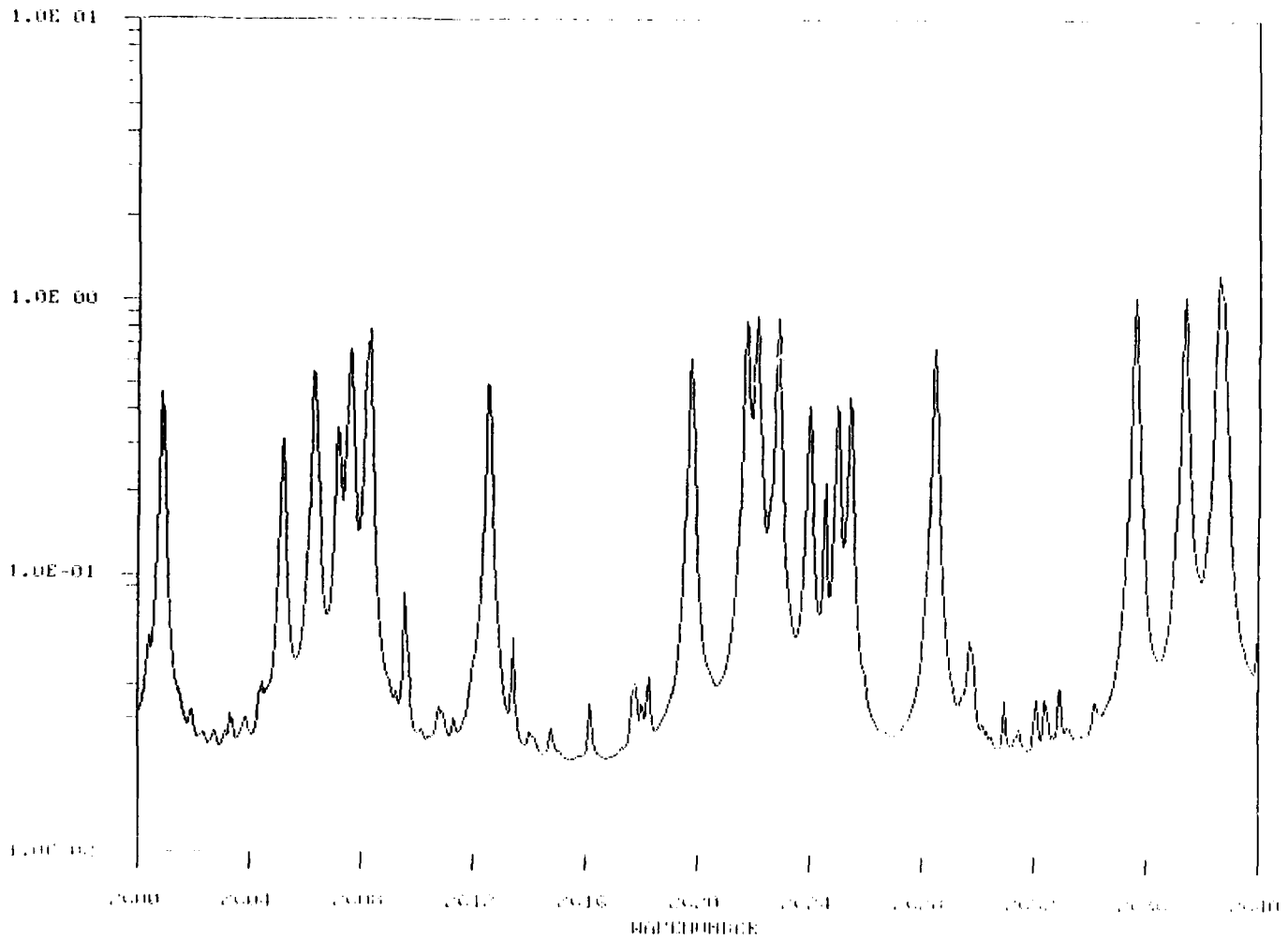

Fig. 18 — 2600-2640 cm^{-1} atmospheric absorption coefficient (km^{-1})

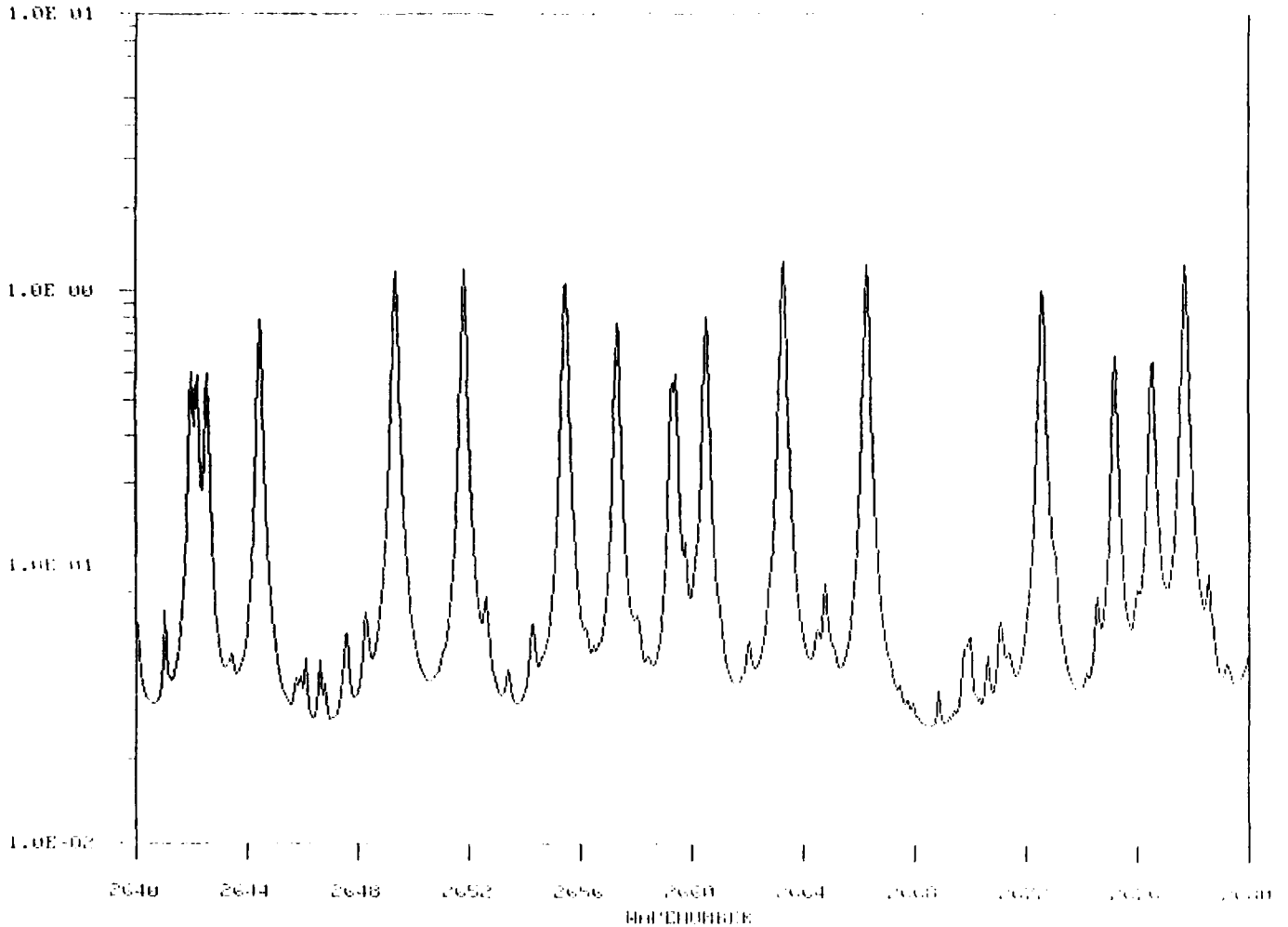

Fig. 19 — 2640-2680 cm^{-1} atmospheric absorption coefficient (km^{-1})

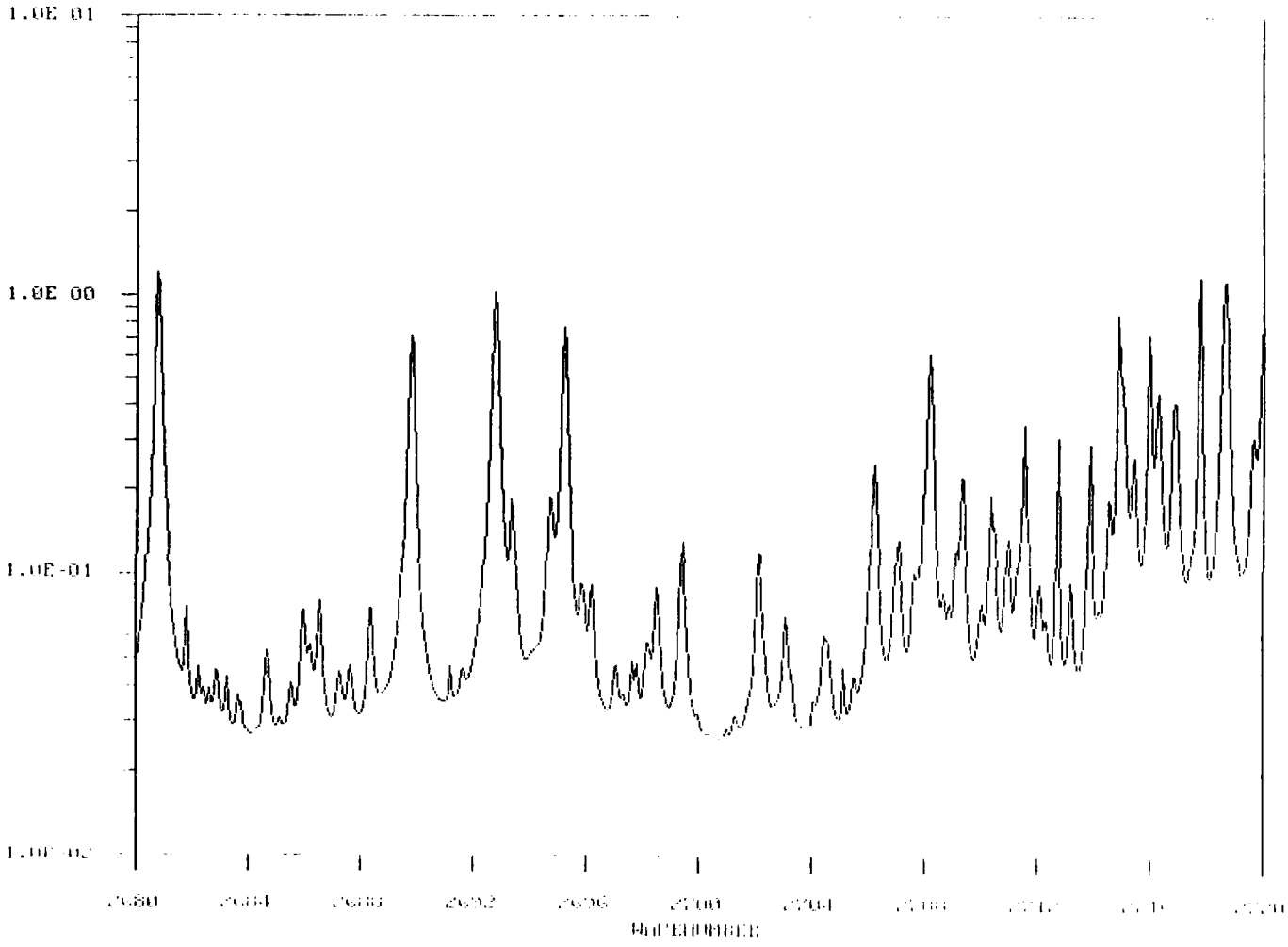

Fig. 20 — 2680-2720 cm^{-1} atmospheric absorption coefficient (km^{-1})

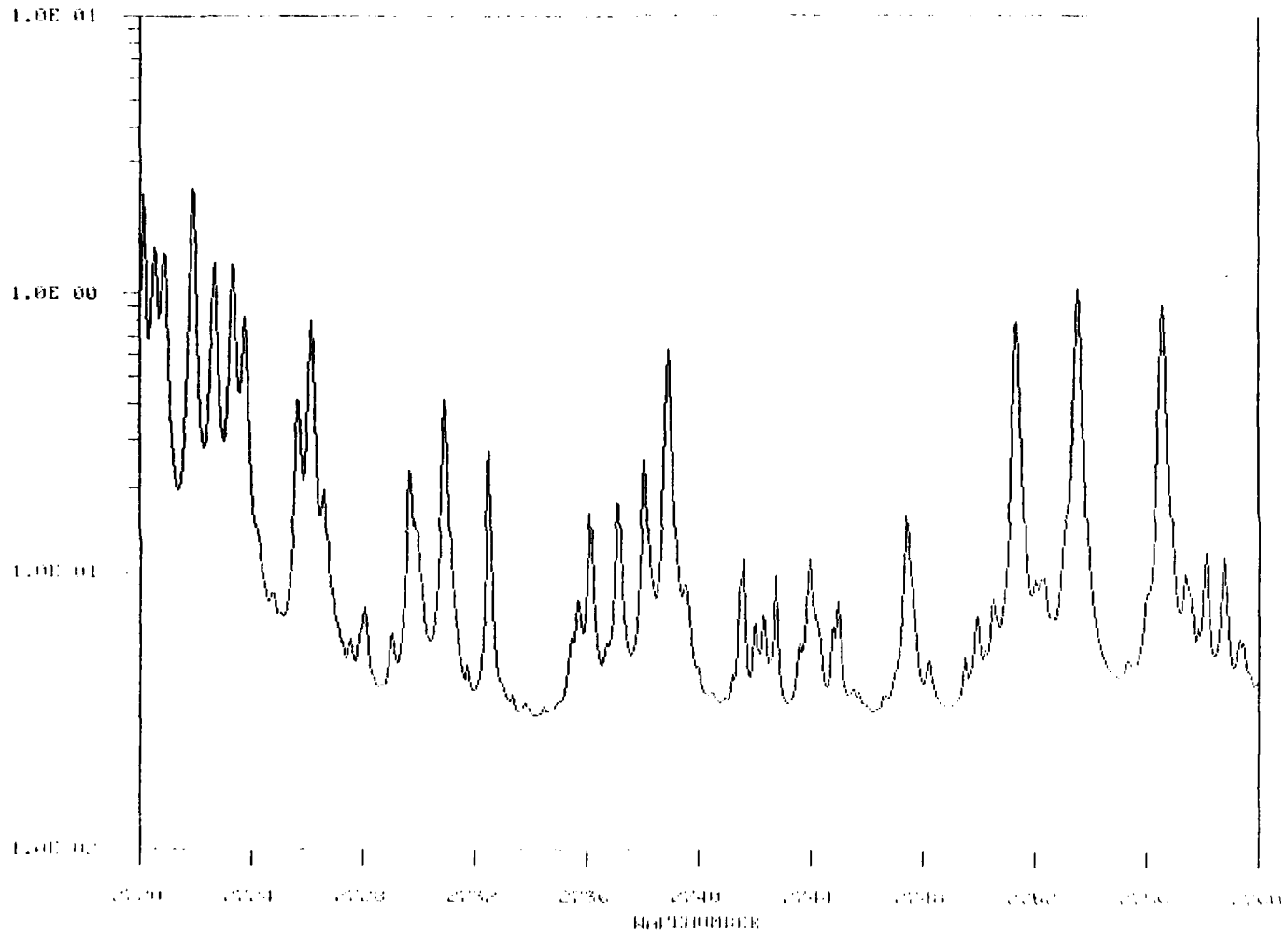

Fig. 21 — 2720-2760 cm^{-1} atmospheric absorption coefficient (km^{-1})

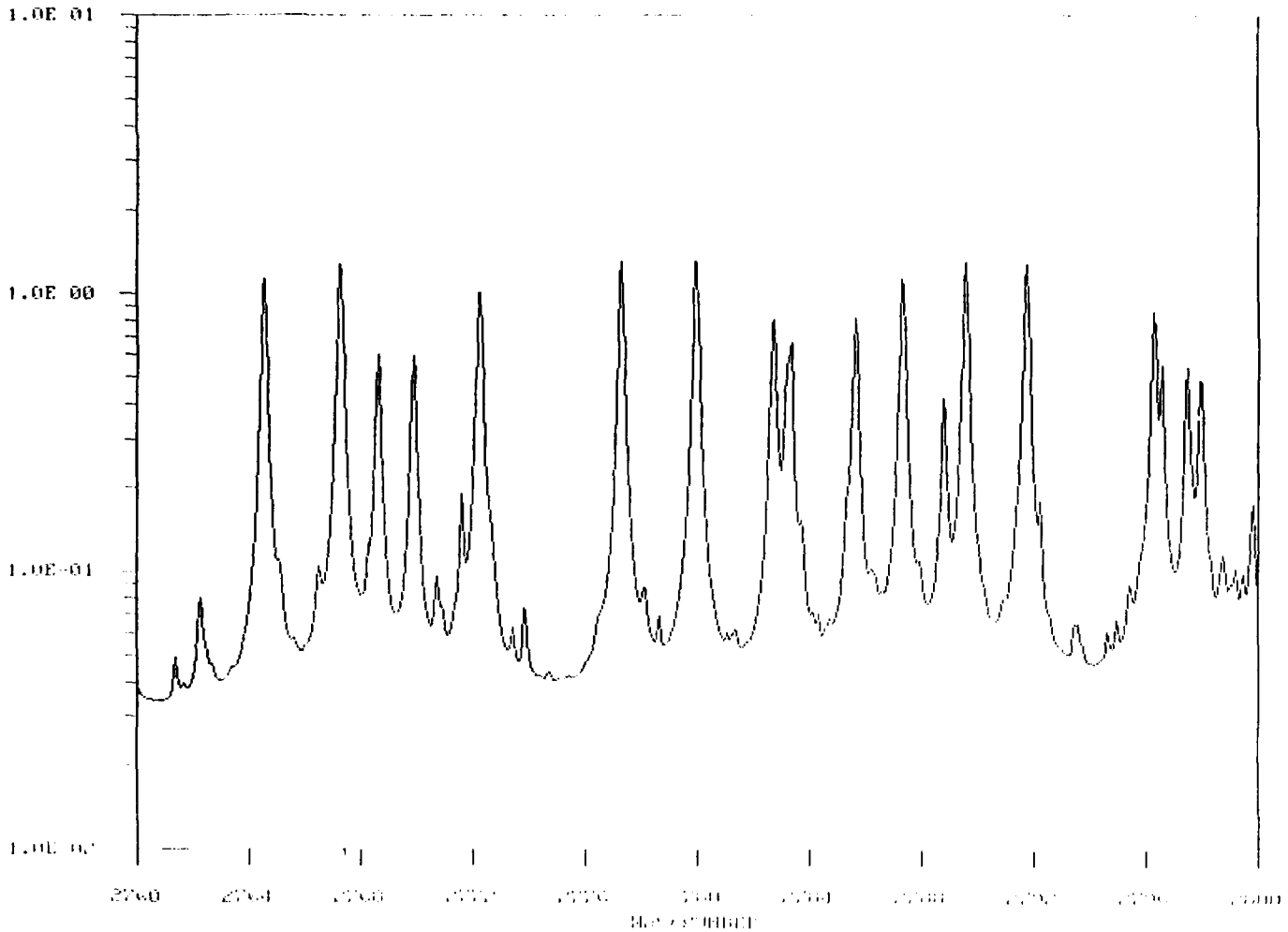

Fig. 22 — 2760-2800 cm^{-1} atmospheric absorption coefficient (km^{-1})

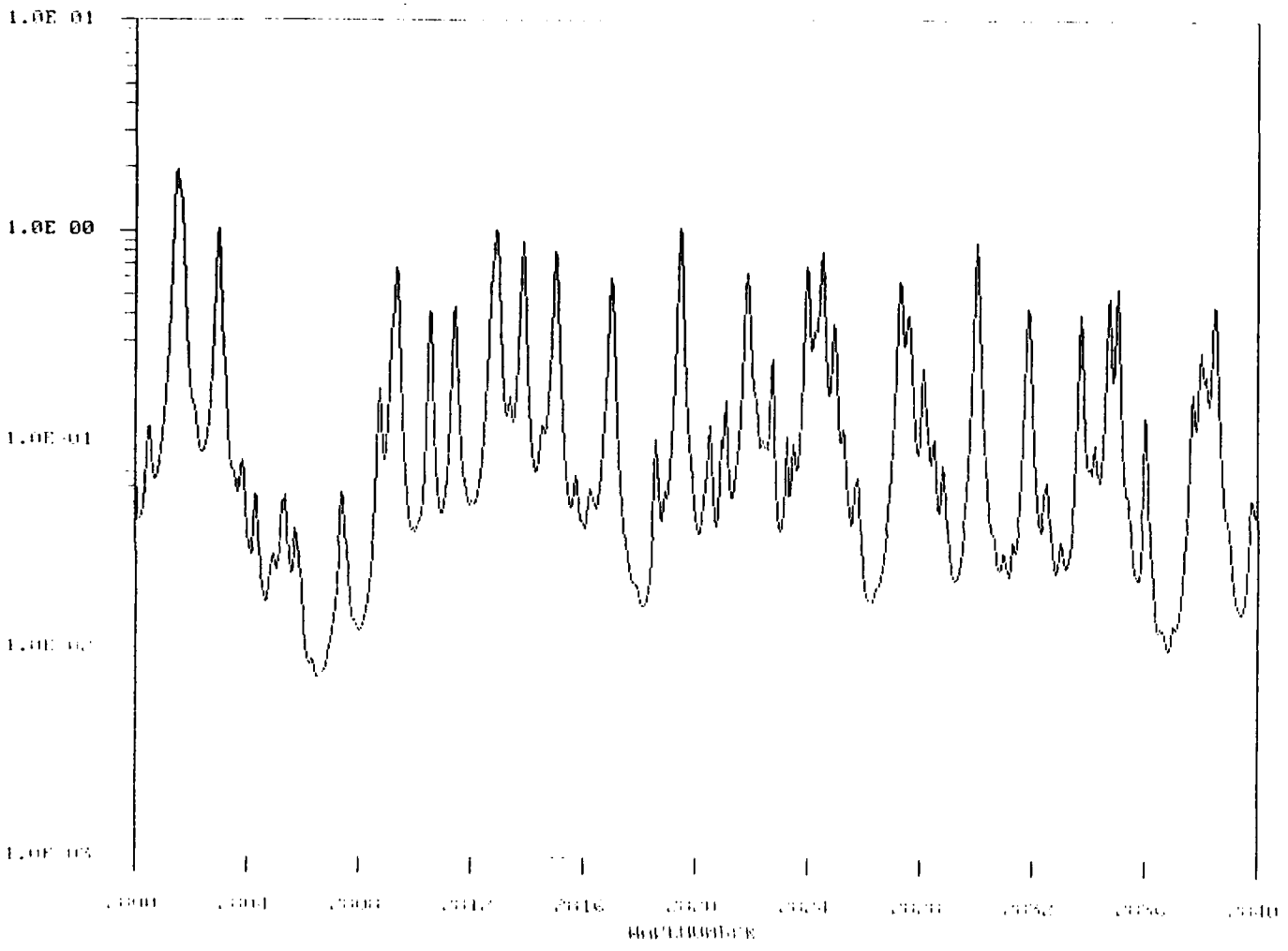

Fig. 23 — 2800-2840 cm^{-1} atmospheric absorption coefficient (km^{-1})

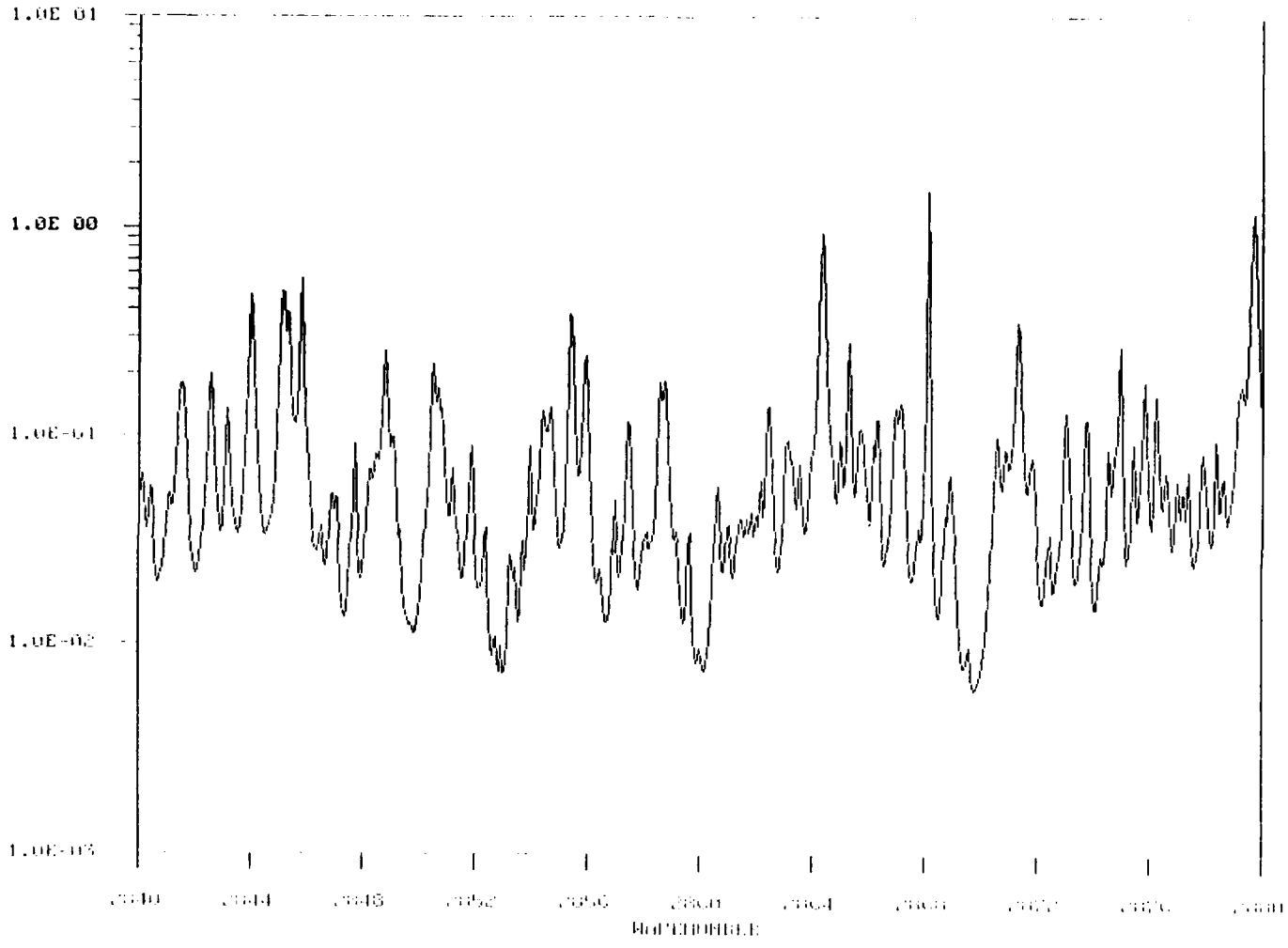

Fig. 24 — 2840-2880 cm^{-1} atmospheric absorption coefficient (km^{-1})

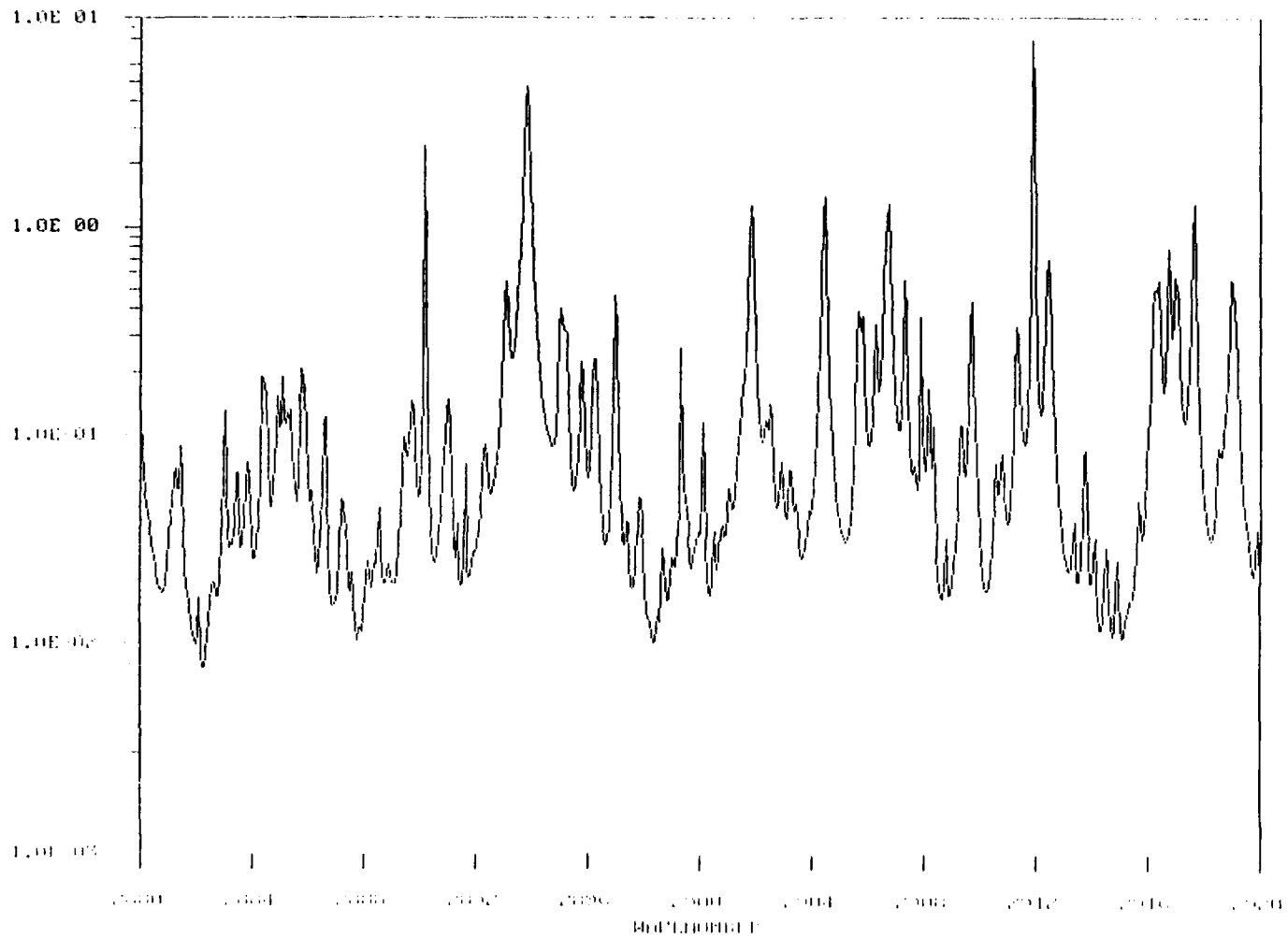

Fig. 25 — 2880-2920 cm^{-1} atmospheric absorption coefficient (km^{-1})

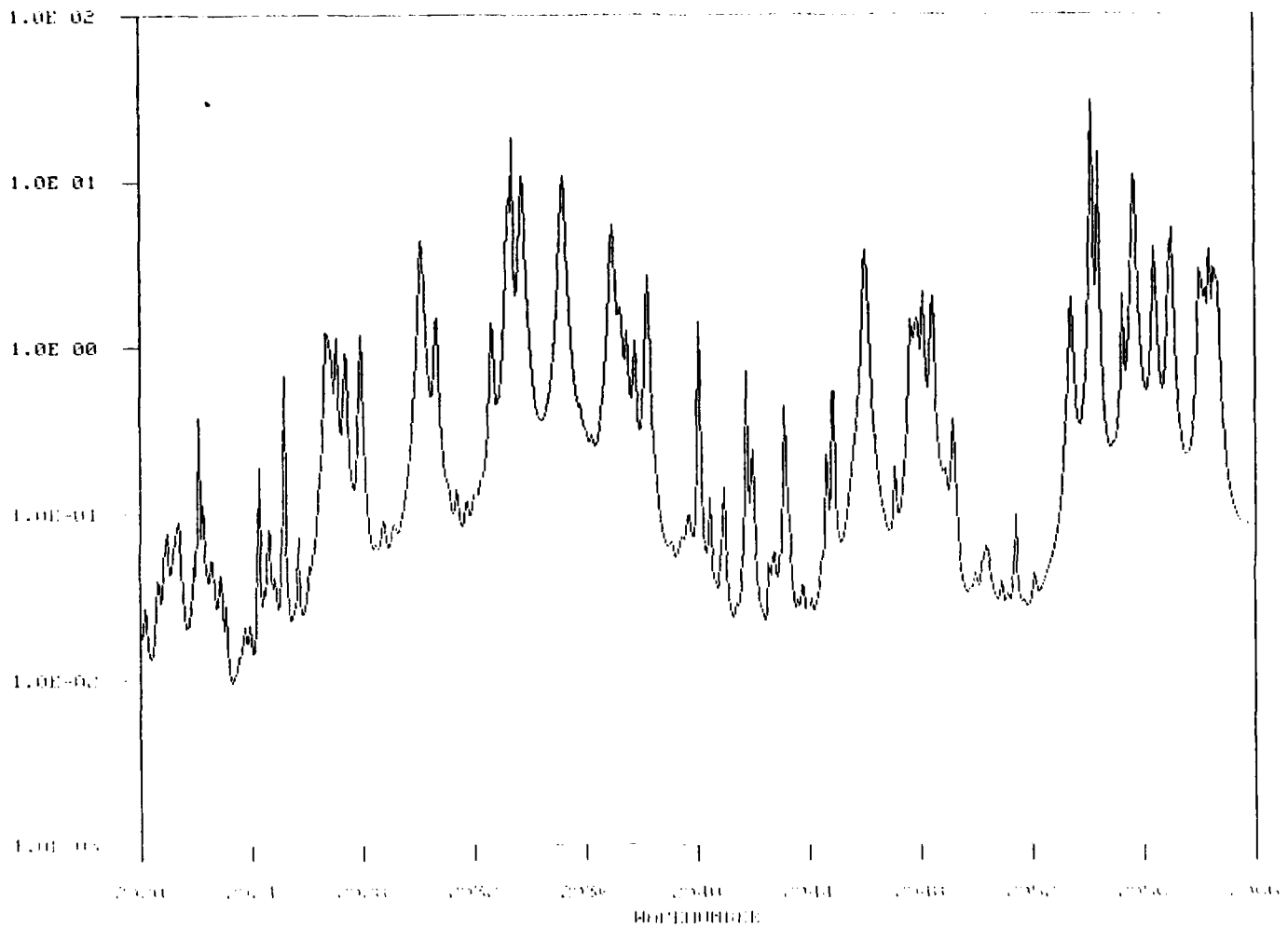

Fig. 26 — 2920-2960 cm^{-1} atmospheric absorption coefficient (km^{-1})

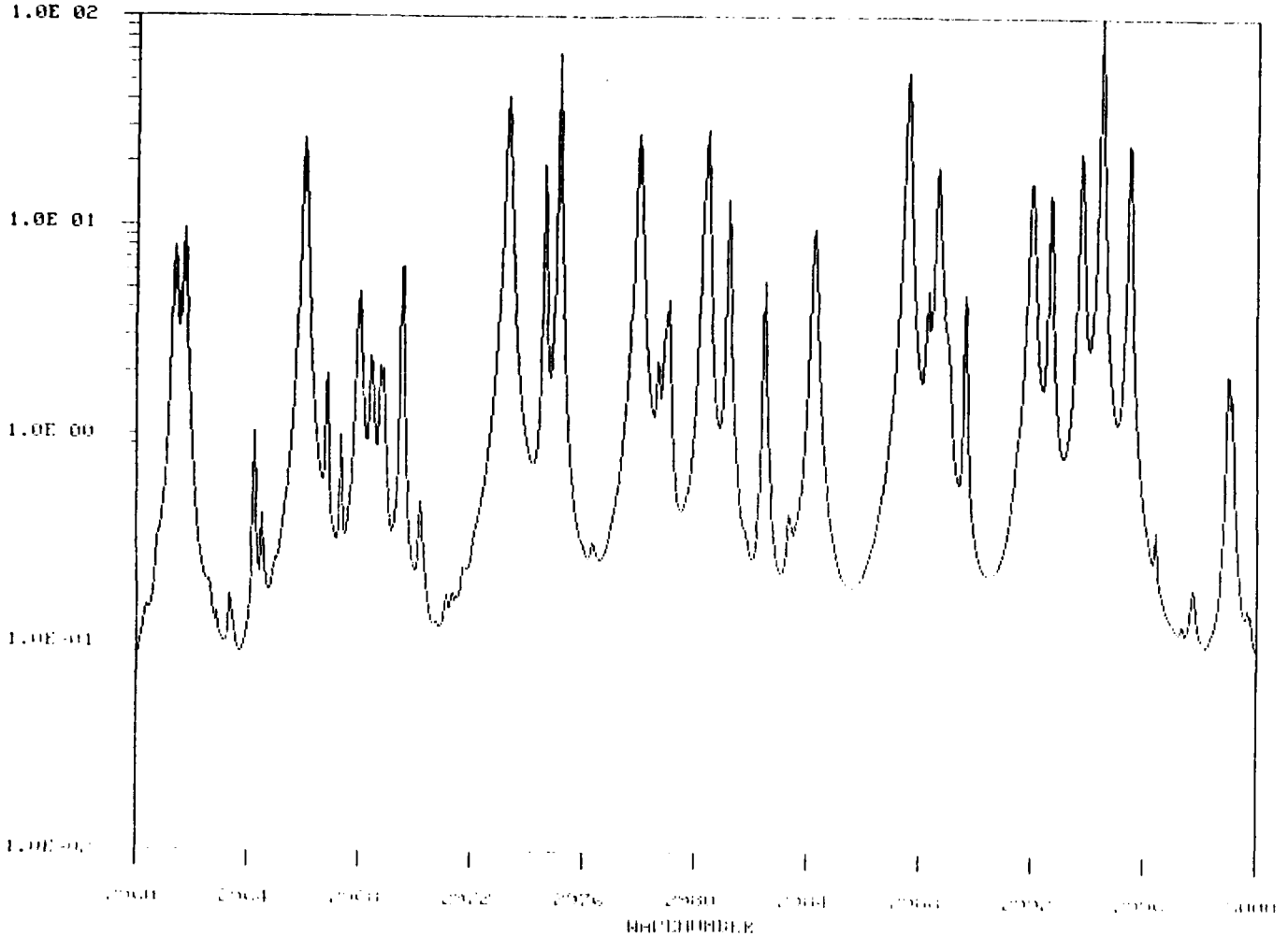

Fig. 27 — 2960-3000 cm^{-1} atmospheric absorption coefficient (km^{-1})

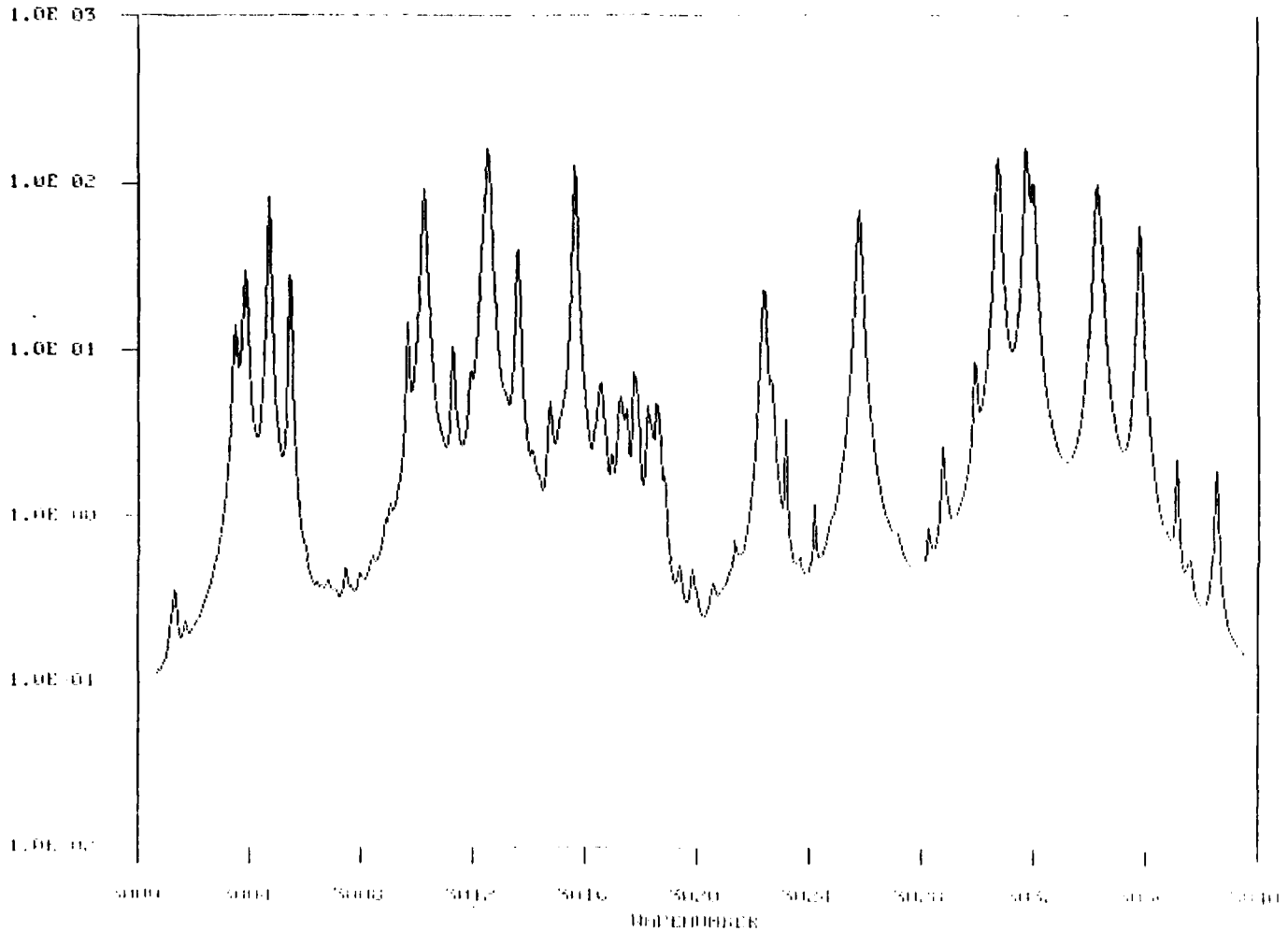

Fig. 28 — 3000-3040 cm^{-1} atmospheric absorption coefficient (km^{-1})

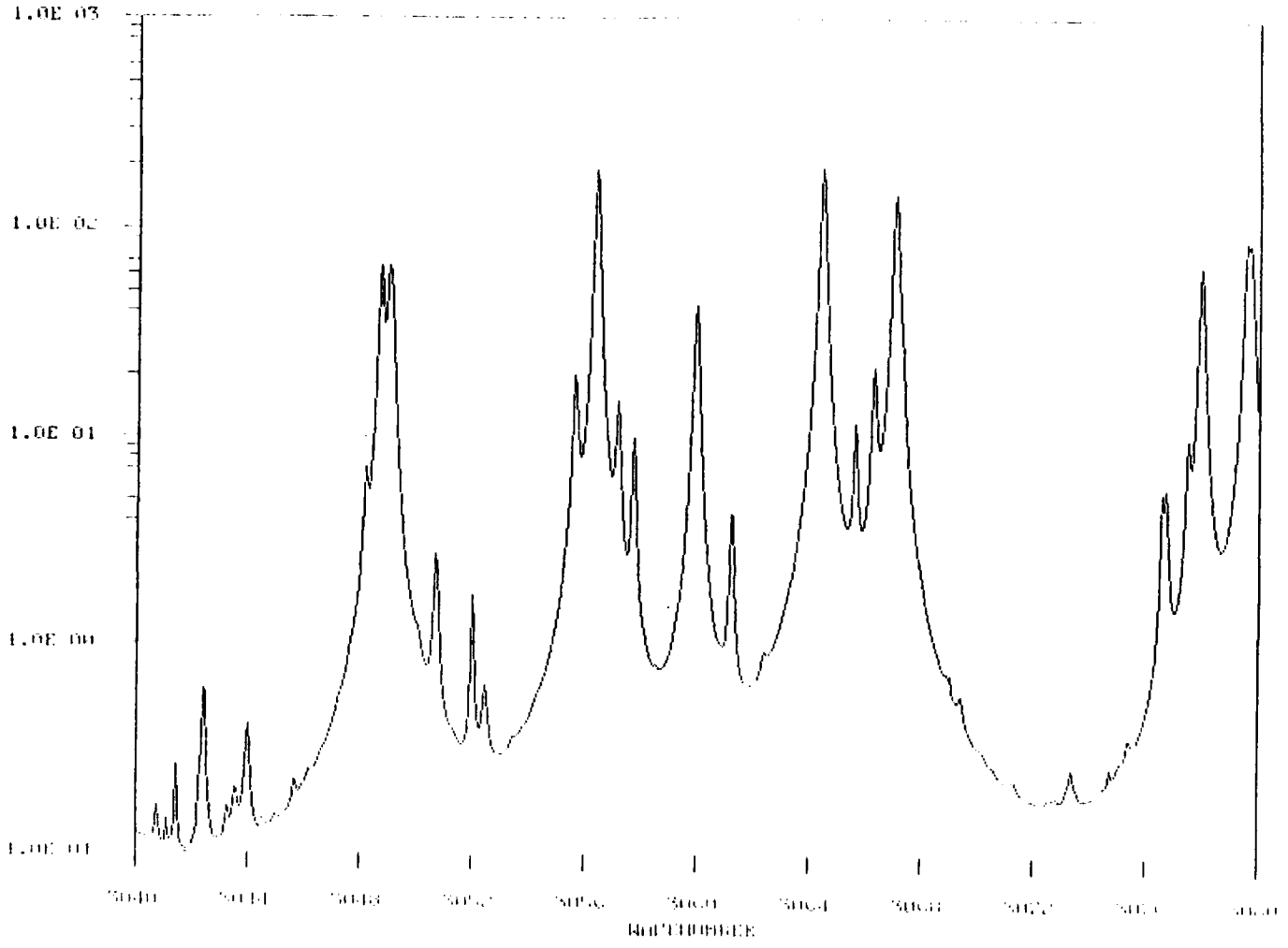

Fig. 29 — 3040-3080 cm^{-1} atmospheric absorption coefficient (km^{-1})

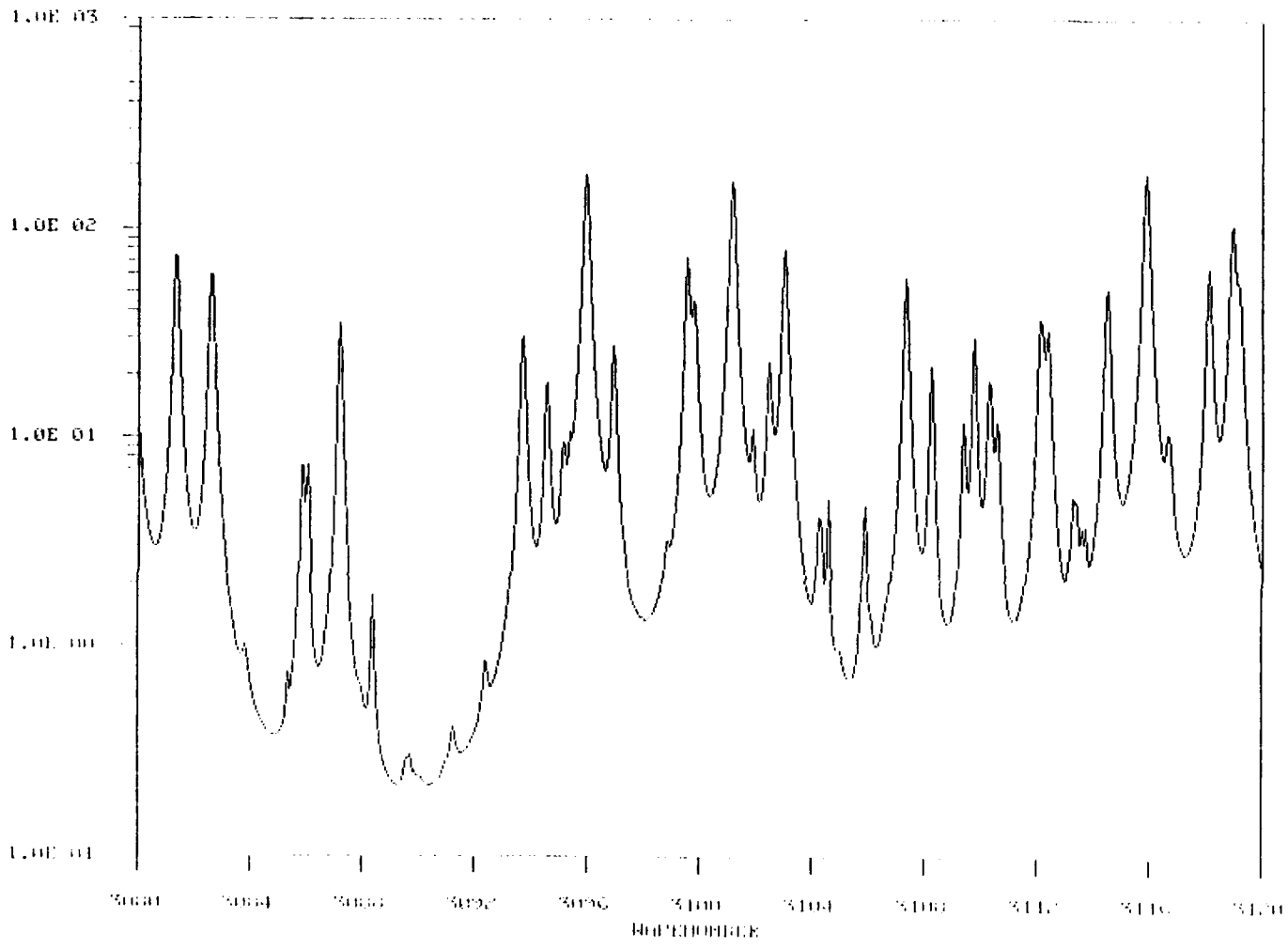

Fig. 30 — 3080-3120 cm^{-1} atmospheric absorption coefficient (km^{-1})

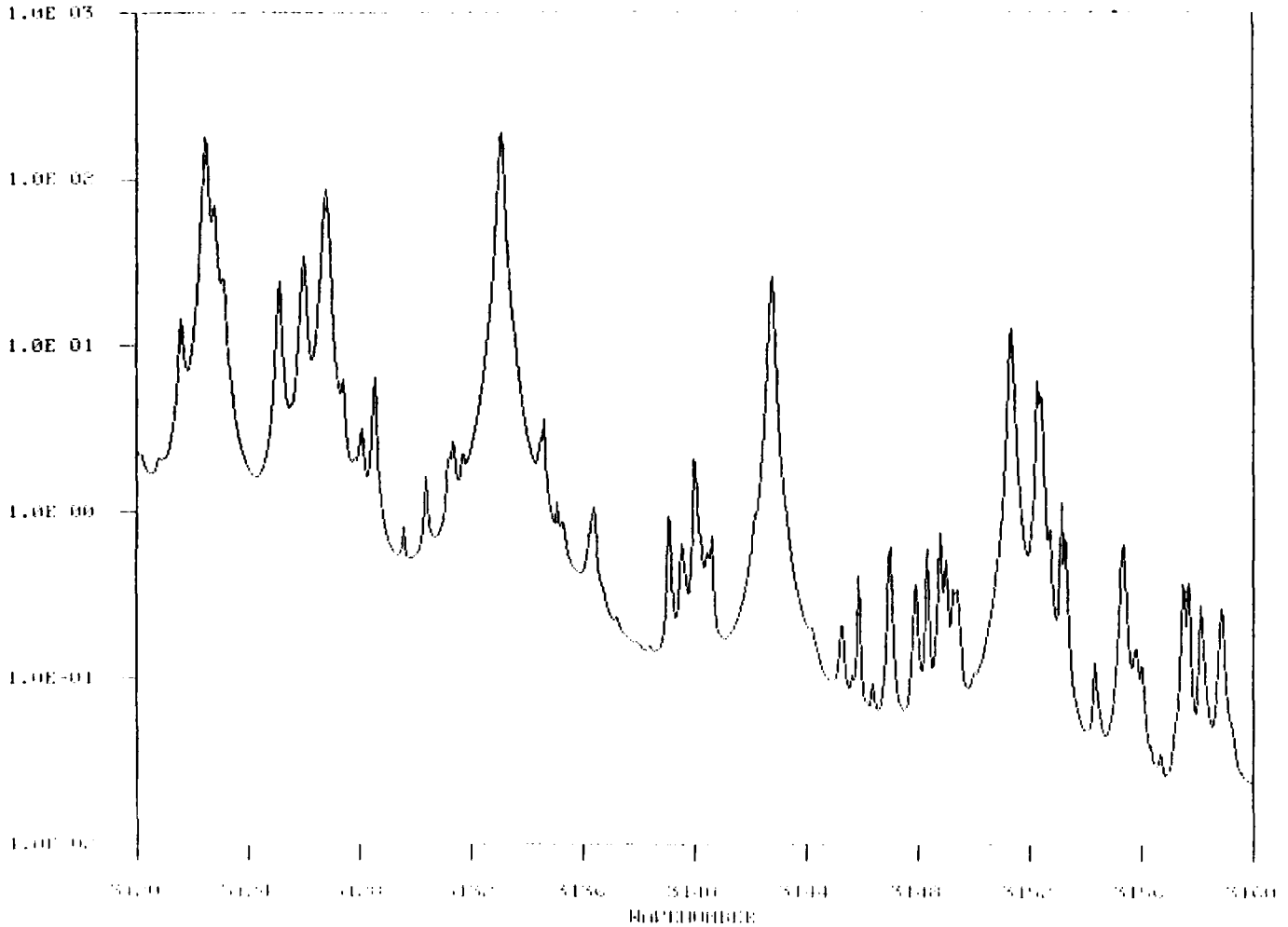

Fig. 31 — 3120-3160 cm^{-1} atmospheric absorption coefficient (km^{-1})

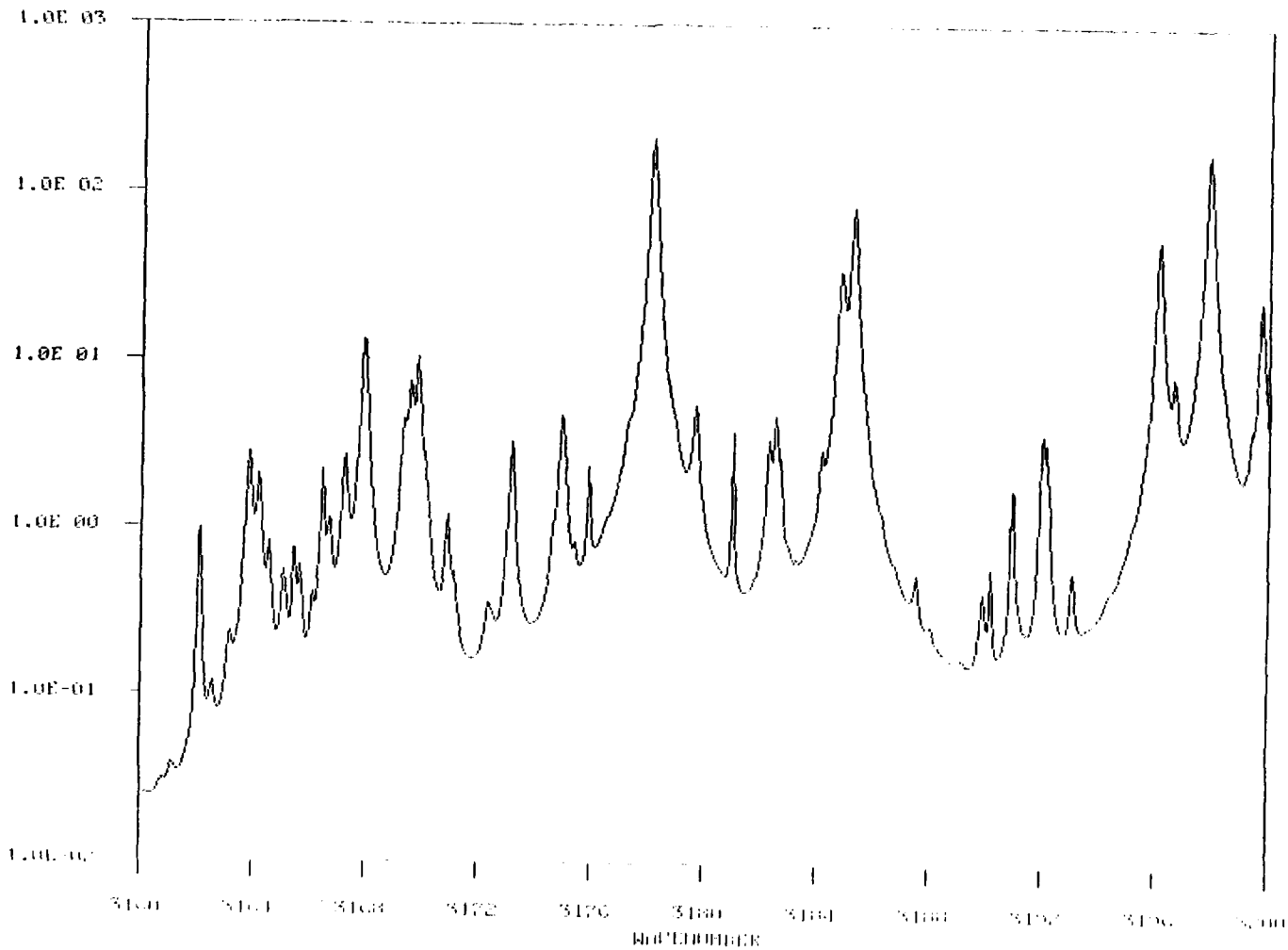

Fig. 32 — 3160-3200 cm^{-1} atmospheric absorption coefficient (km^{-1})

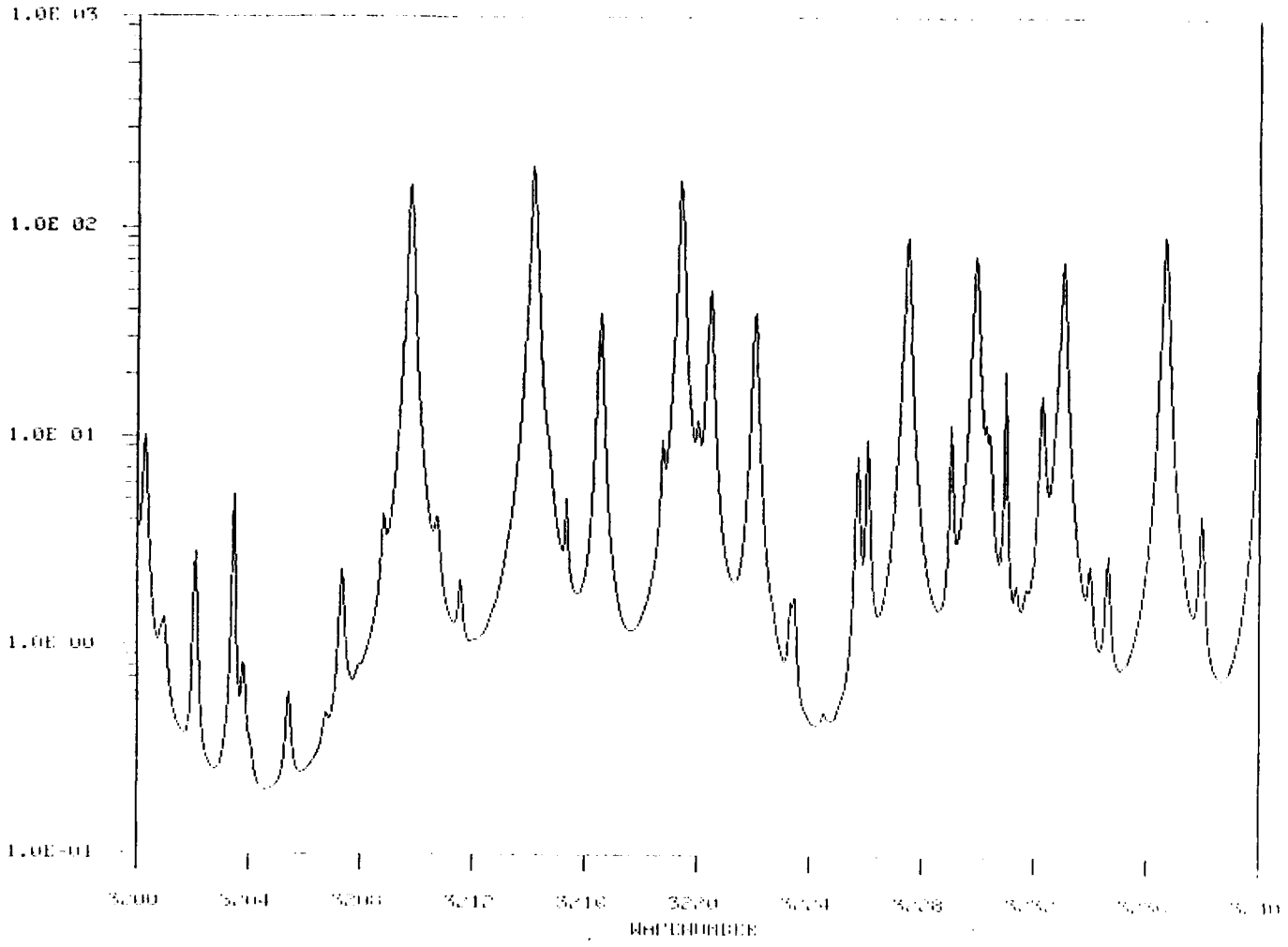

Fig. 33 — 3200-3240 cm^{-1} atmospheric absorption coefficient (km^{-1})

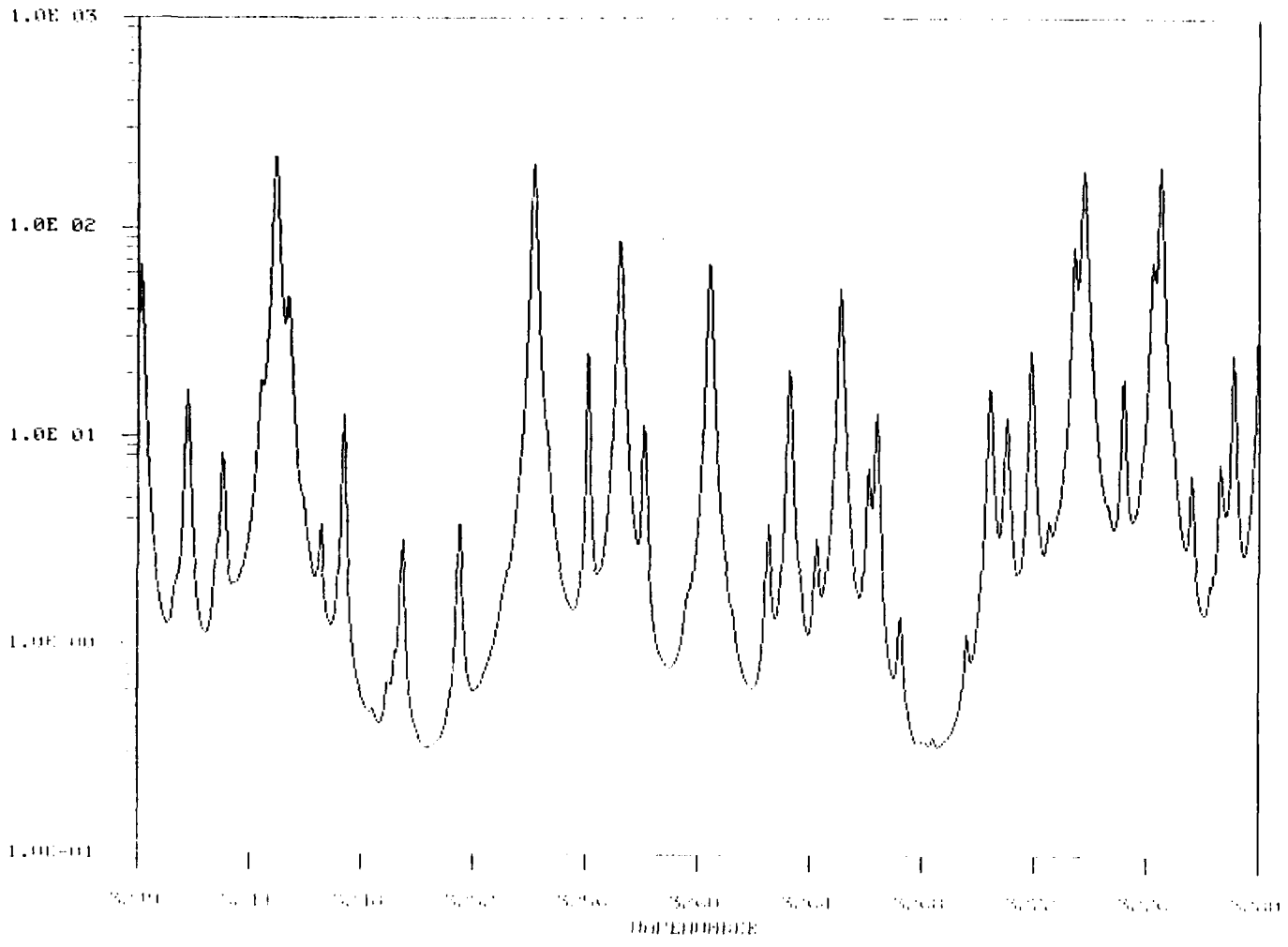

Fig. 34 — 3240-3280 cm^{-1} atmospheric absorption coefficient (km^{-1})

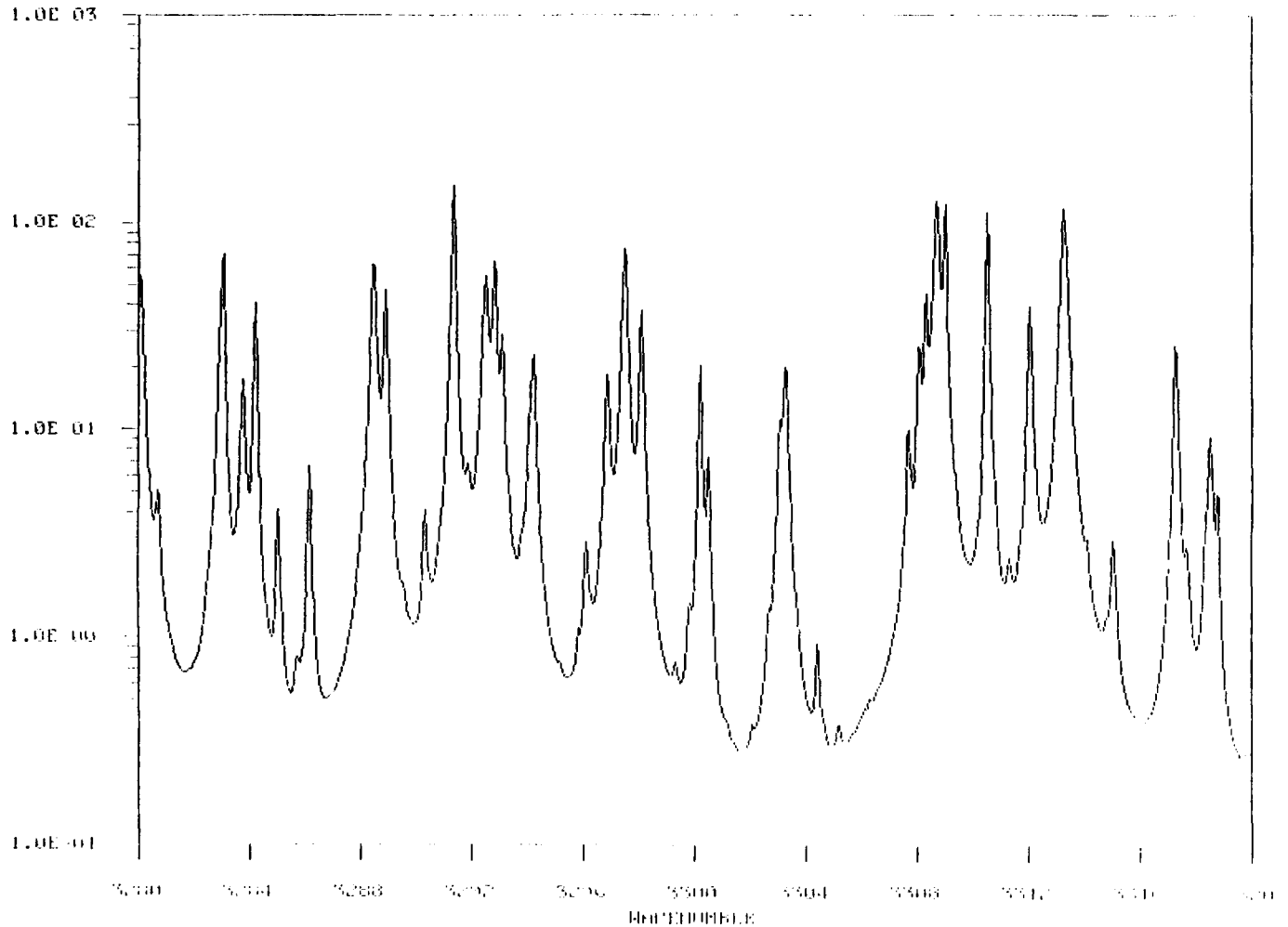

Fig. 35 — 3320-3280 cm^{-1} atmospheric absorption coefficient (km^{-1})

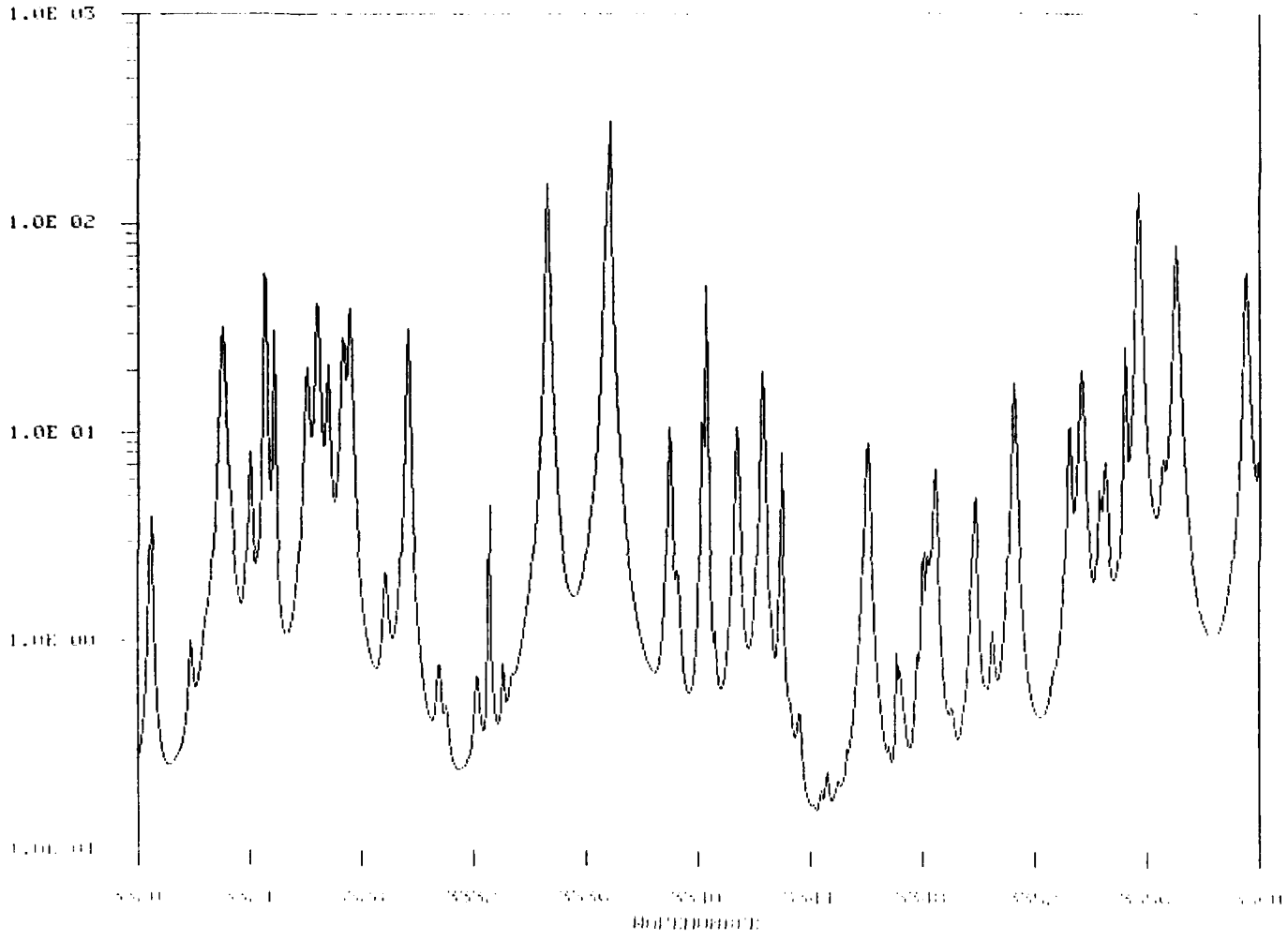

Fig. 36 — 3320-3360 cm^{-1} atmospheric absorption coefficient (km^{-1})

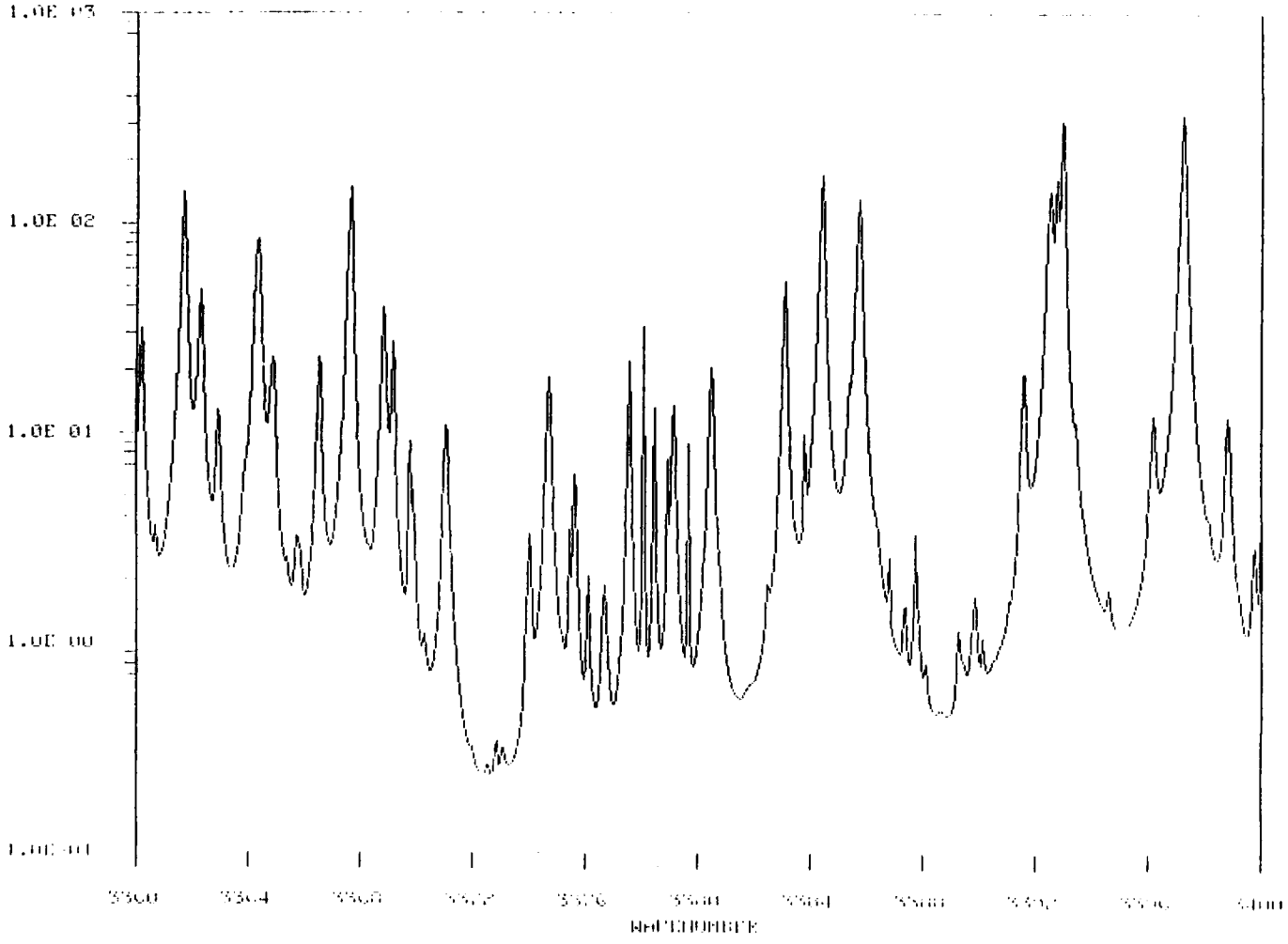

Fig. 37 — 3360-3400 cm^{-1} atmospheric absorption coefficient (km^{-1})

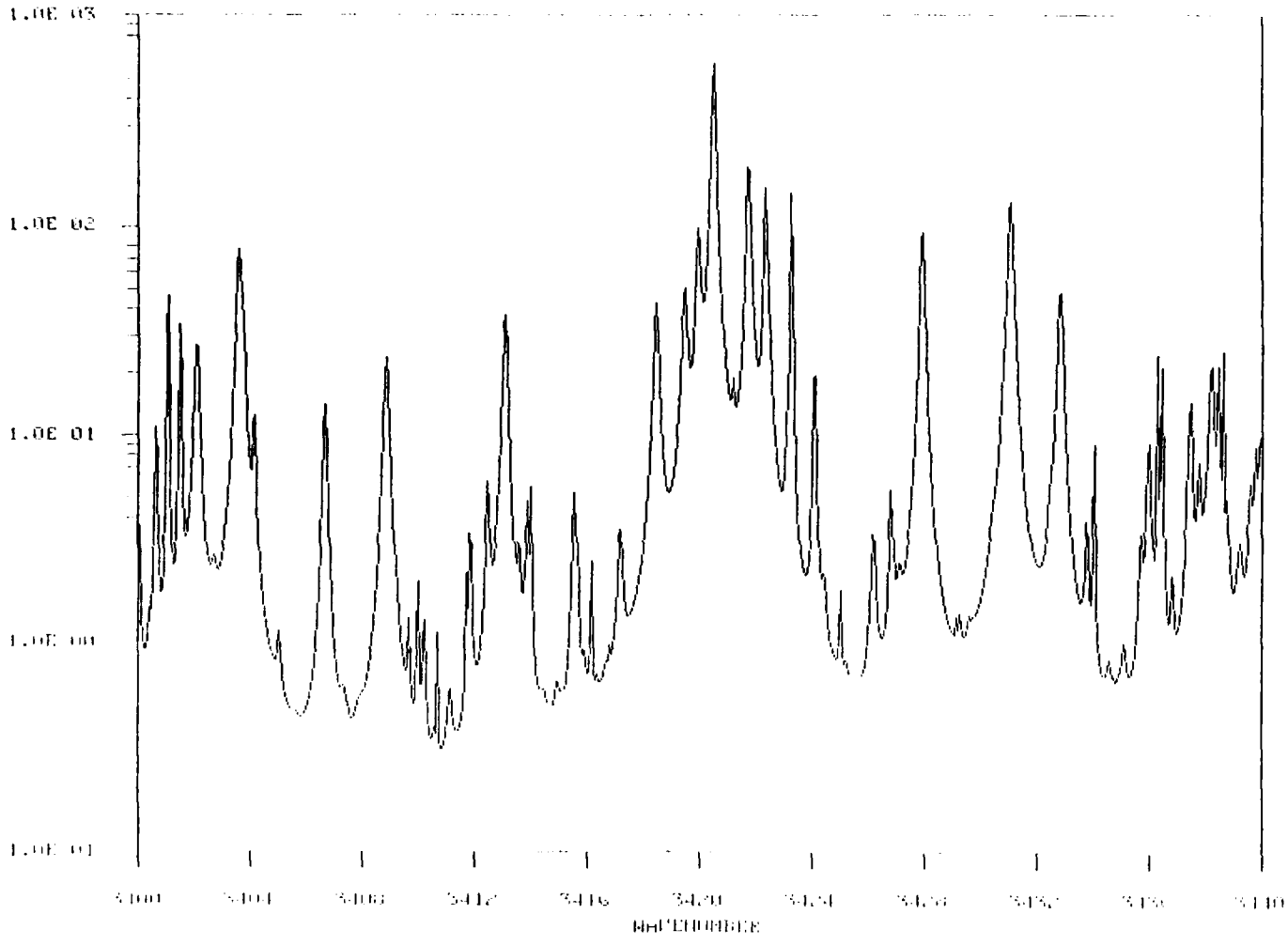

Fig. 38 — 3400-3440 cm^{-1} atmospheric absorption coefficient (km^{-1})

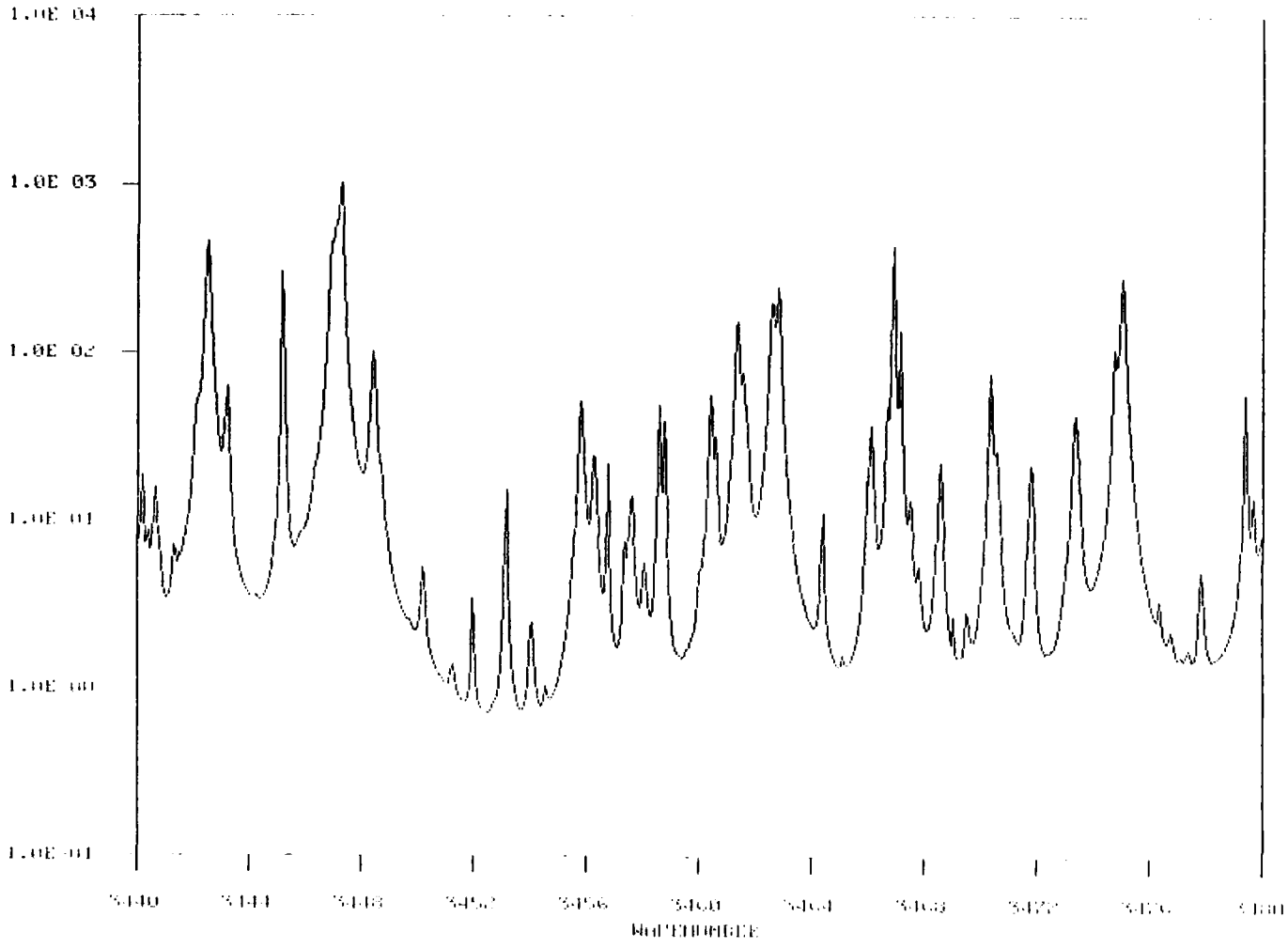

Fig. 39 — 3440-3480 cm^{-1} atmospheric absorption coefficient (km^{-1})

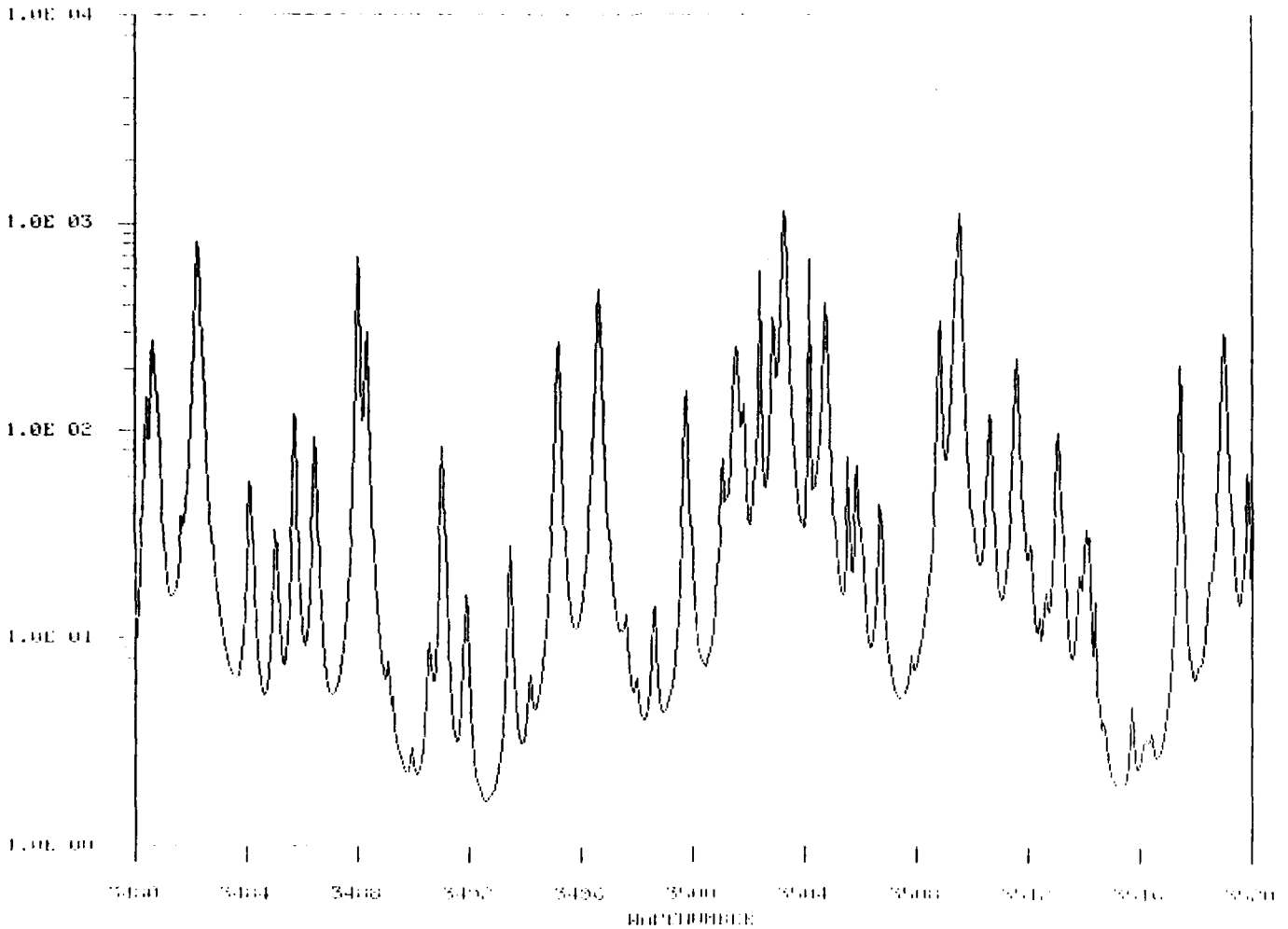

Fig. 40 — 3480-3520 cm^{-1} atmospheric absorption coefficient (km^{-1})

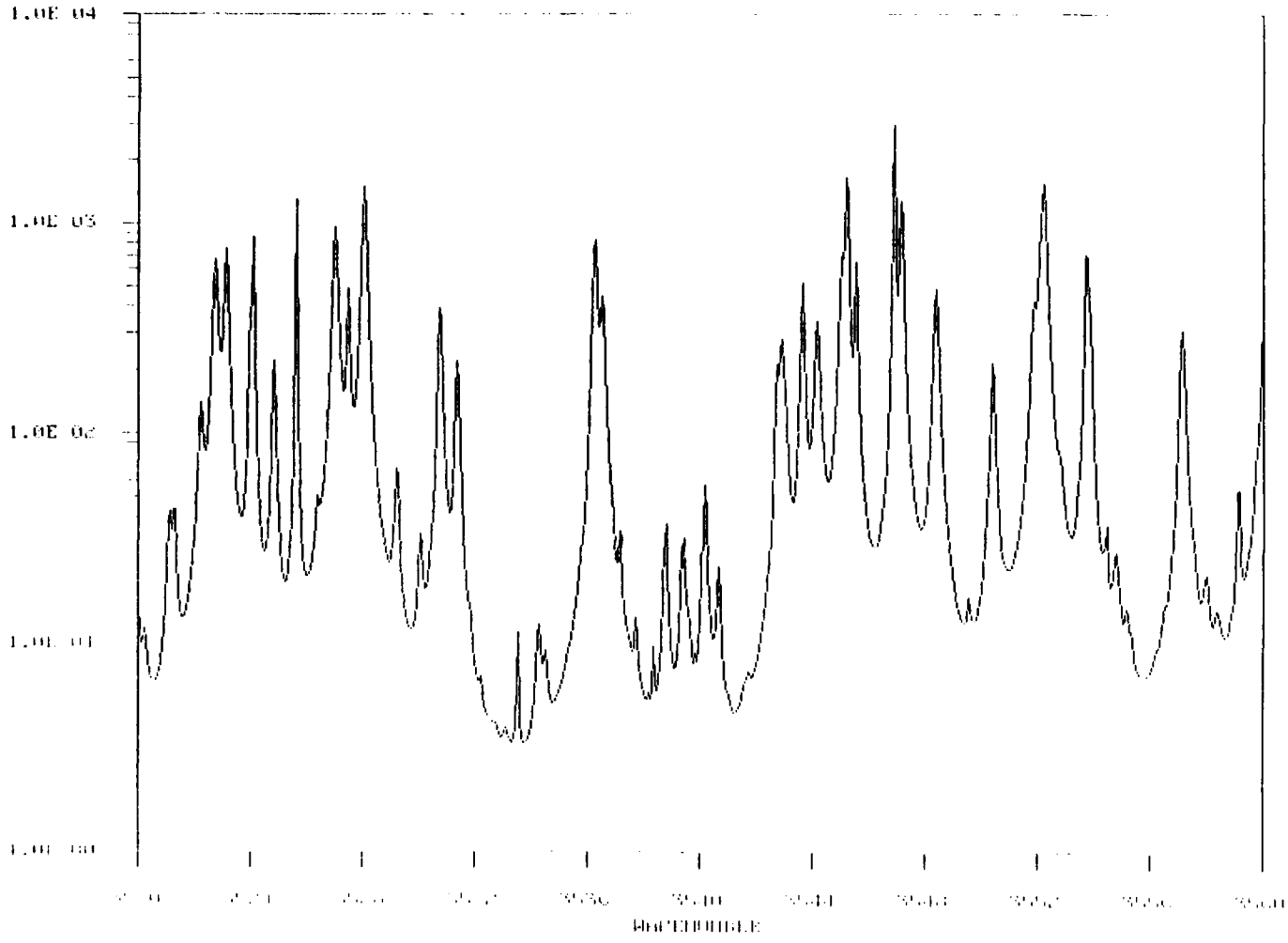

Fig. 41 — 3520-3560 cm^{-1} atmospheric absorption coefficient (km^{-1})

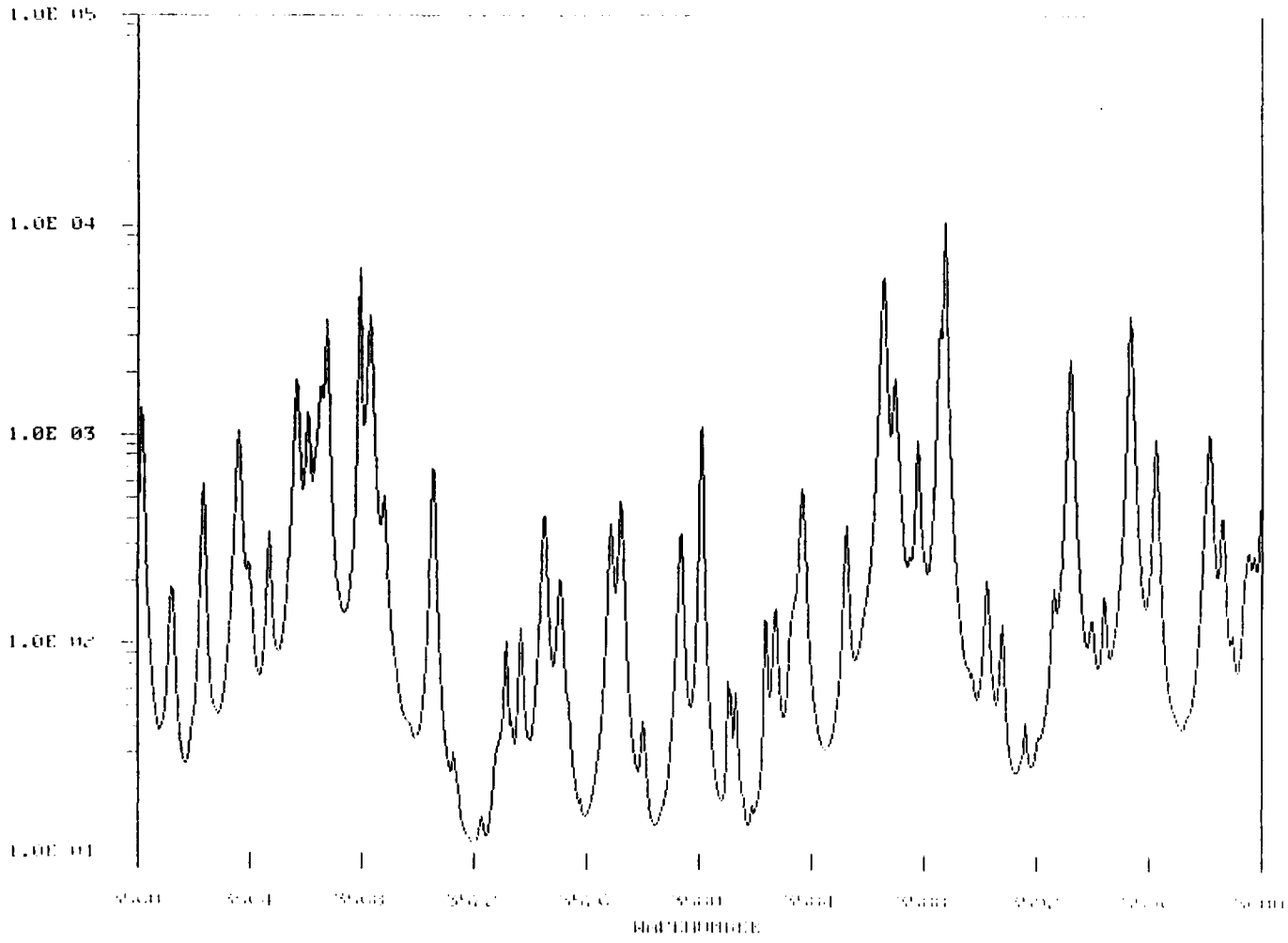

Fig. 42 — 3560-3600 cm^{-1} atmospheric absorption coefficient (km^{-1})

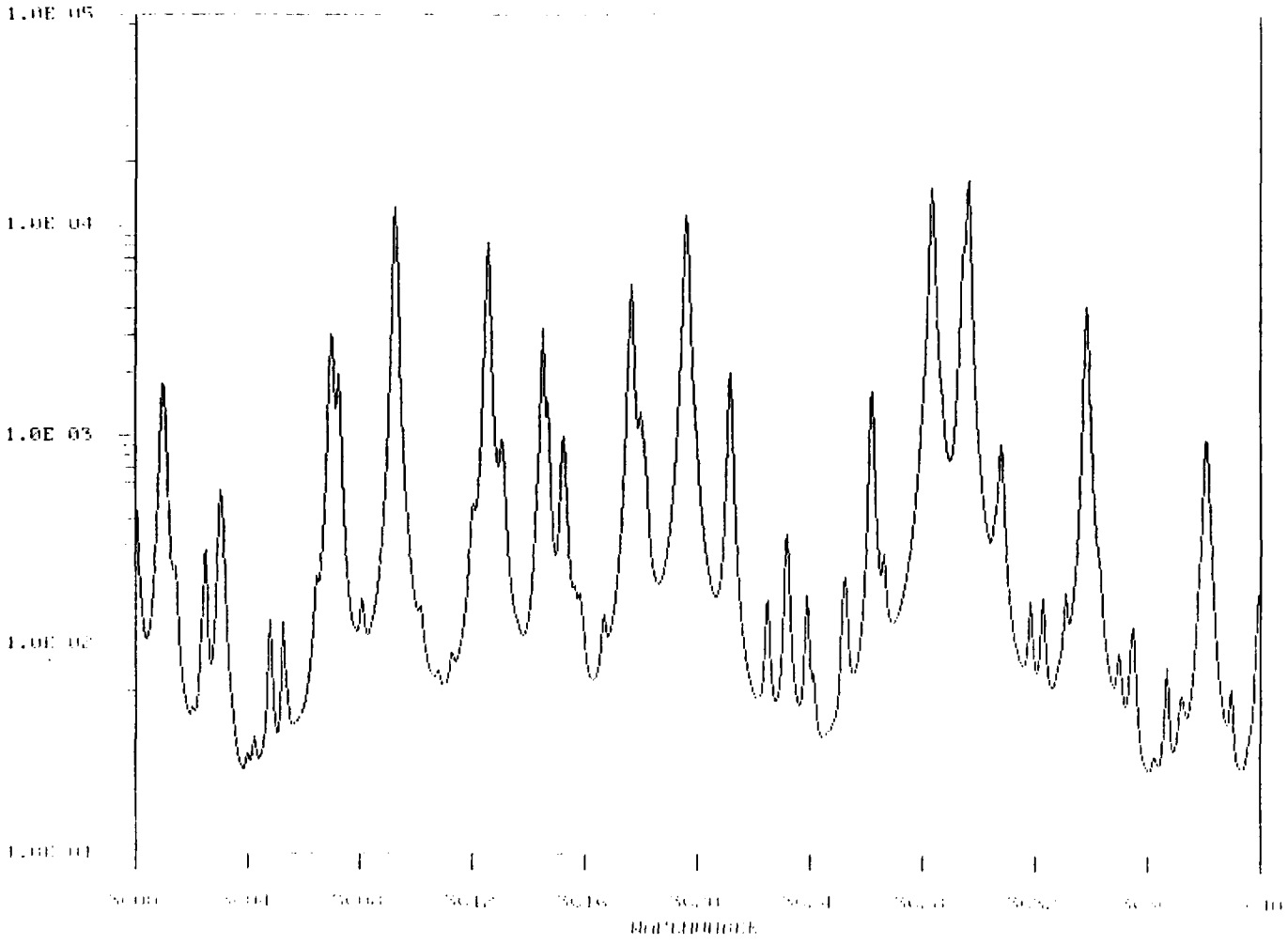

Fig. 43 — 3600-3640 cm^{-1} atmospheric absorption coefficient (km^{-1})

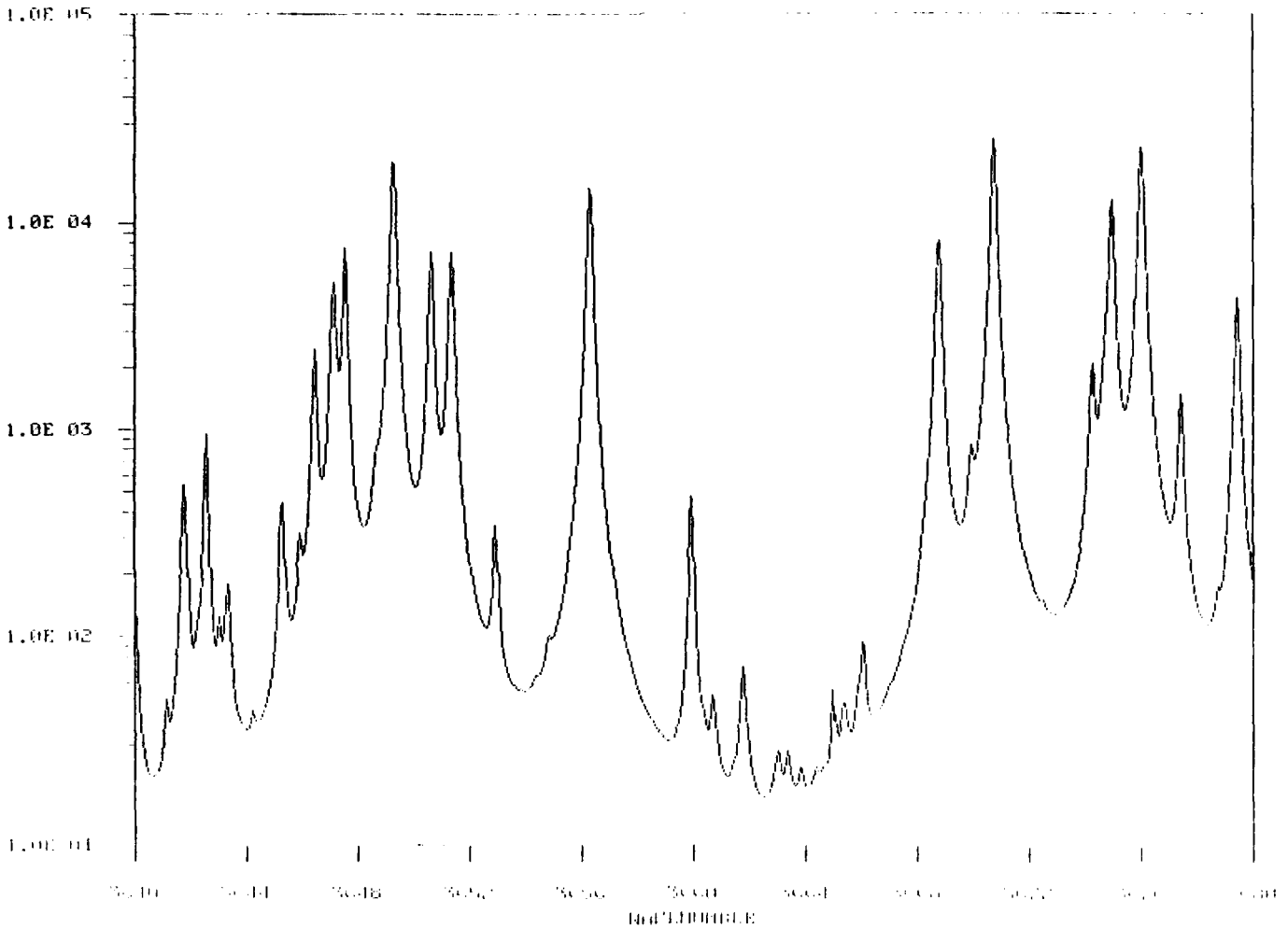

Fig. 44 — 3640-3680 cm^{-1} atmospheric absorption coefficient (km^{-1})

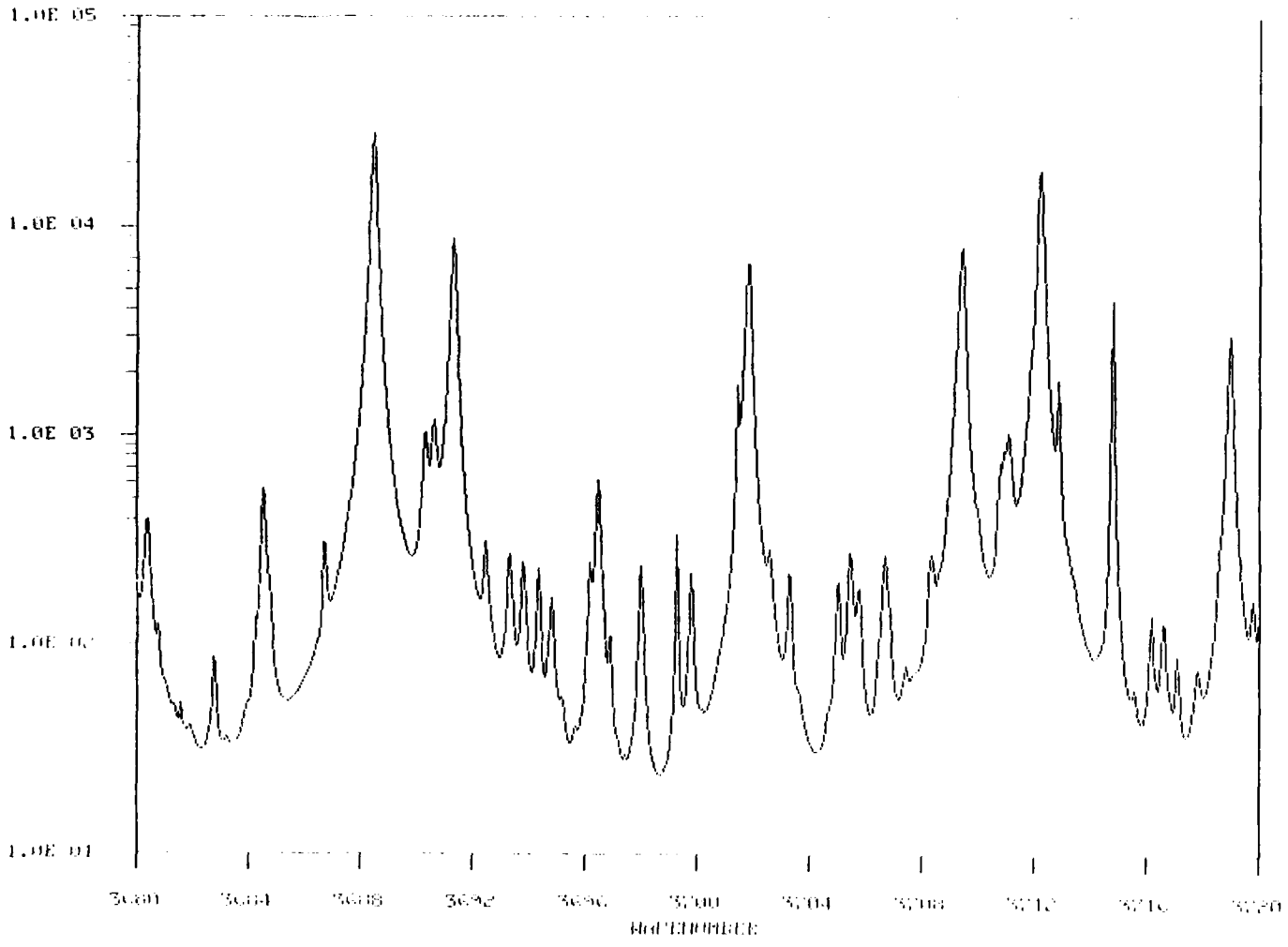

Fig. 45 — 3680-3720 cm^{-1} atmospheric absorption coefficient (km^{-1})

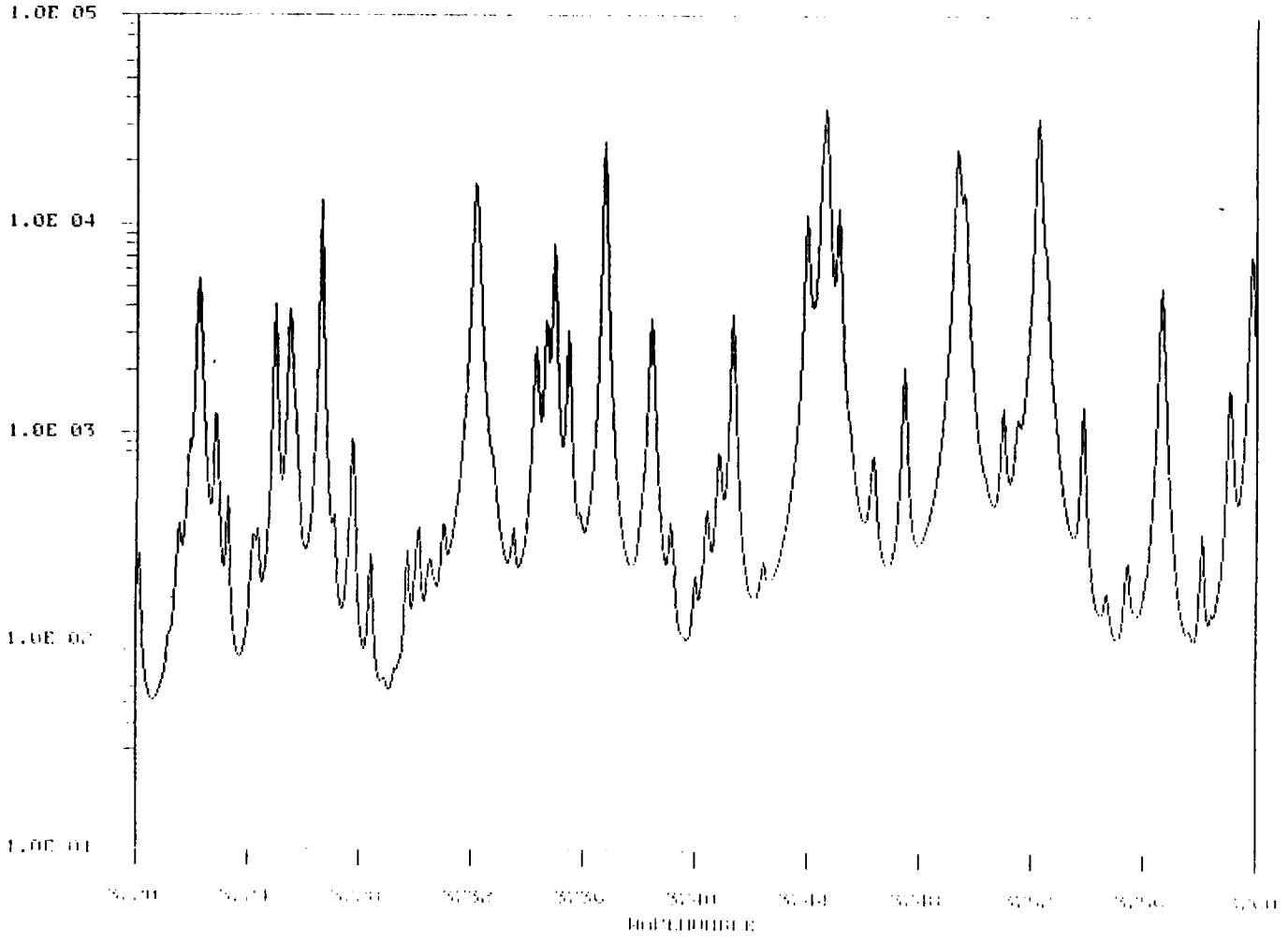

Fig. 46 — 3720-3760 cm^{-1} atmospheric absorption coefficient (km^{-1})

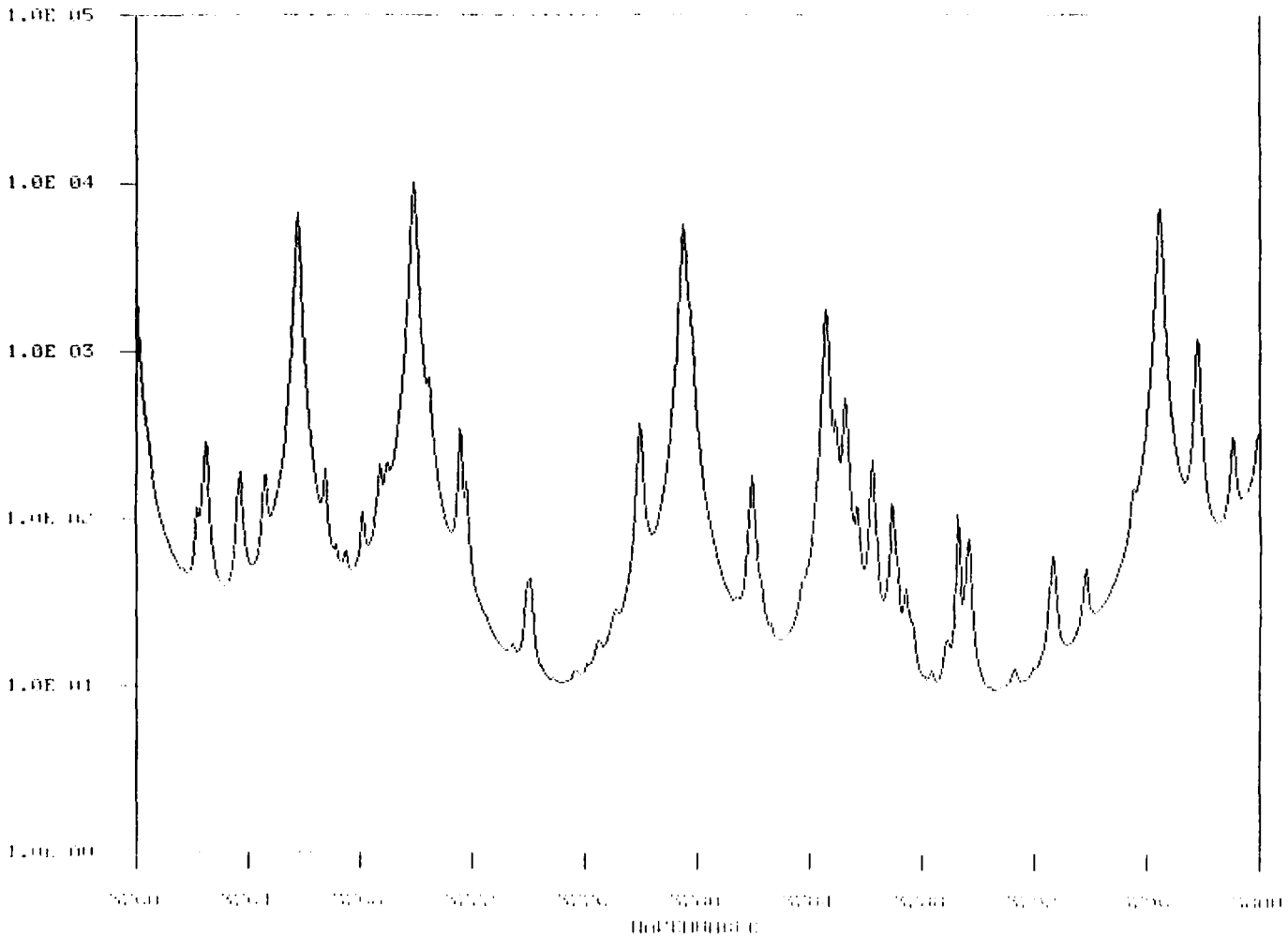

Fig. 47 — 3760-3800 cm^{-1} atmospheric absorption coefficient (km^{-1})

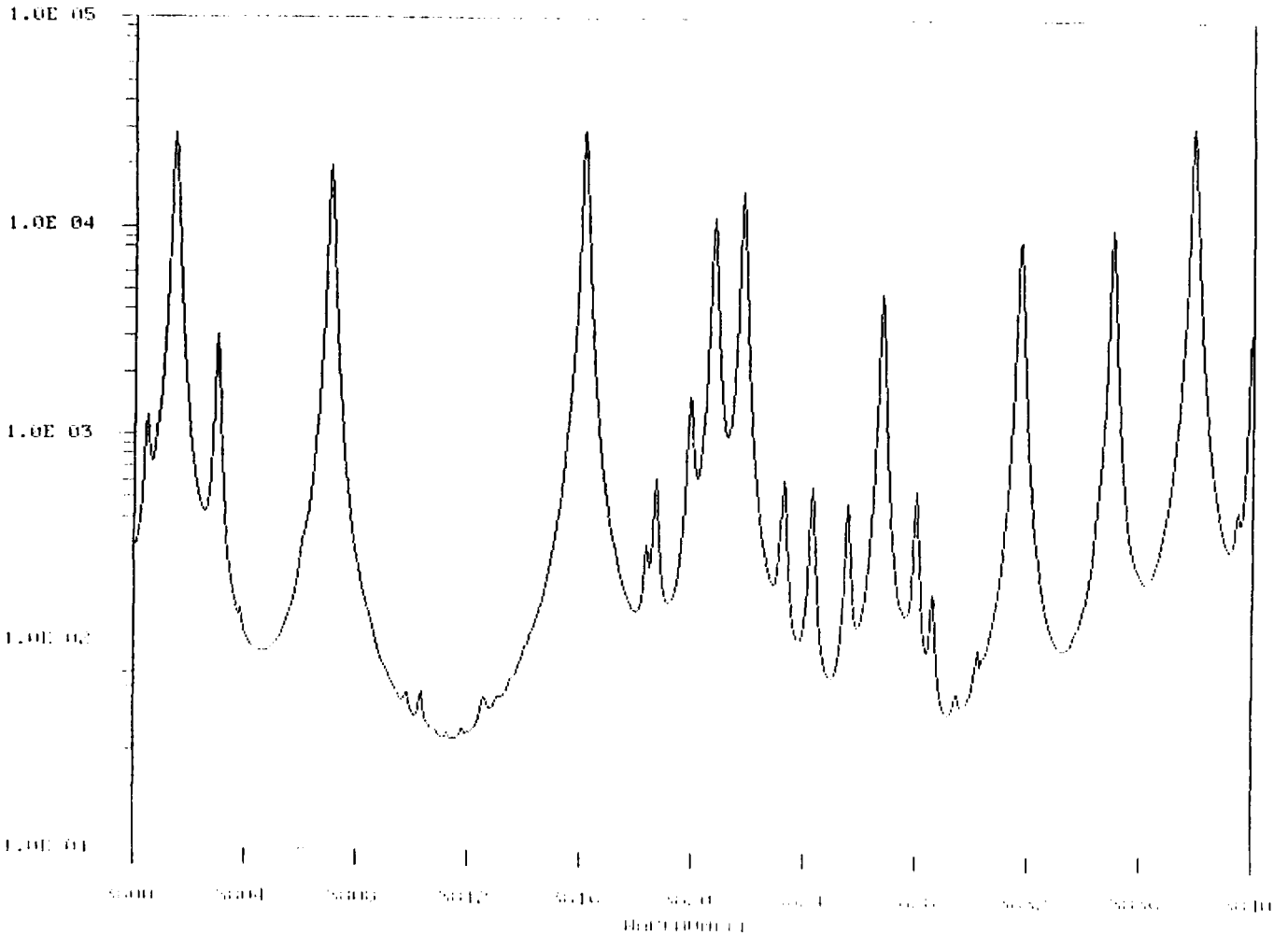

Fig. 48 — 3800-3840 cm^{-1} atmospheric absorption coefficient (km^{-1})

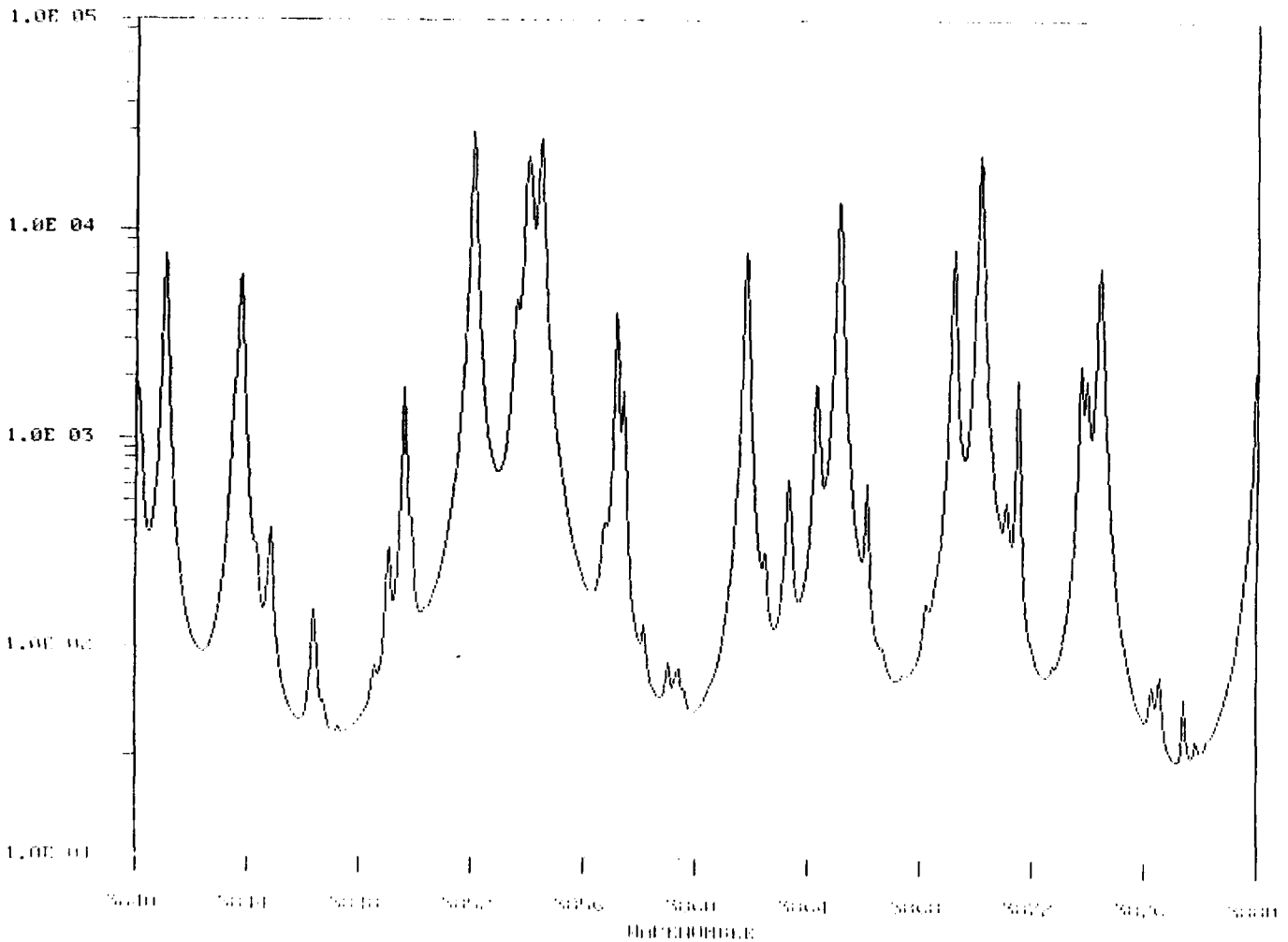

Fig. 49 — 3840-3880 cm^{-1} atmospheric absorption coefficient (km^{-1})

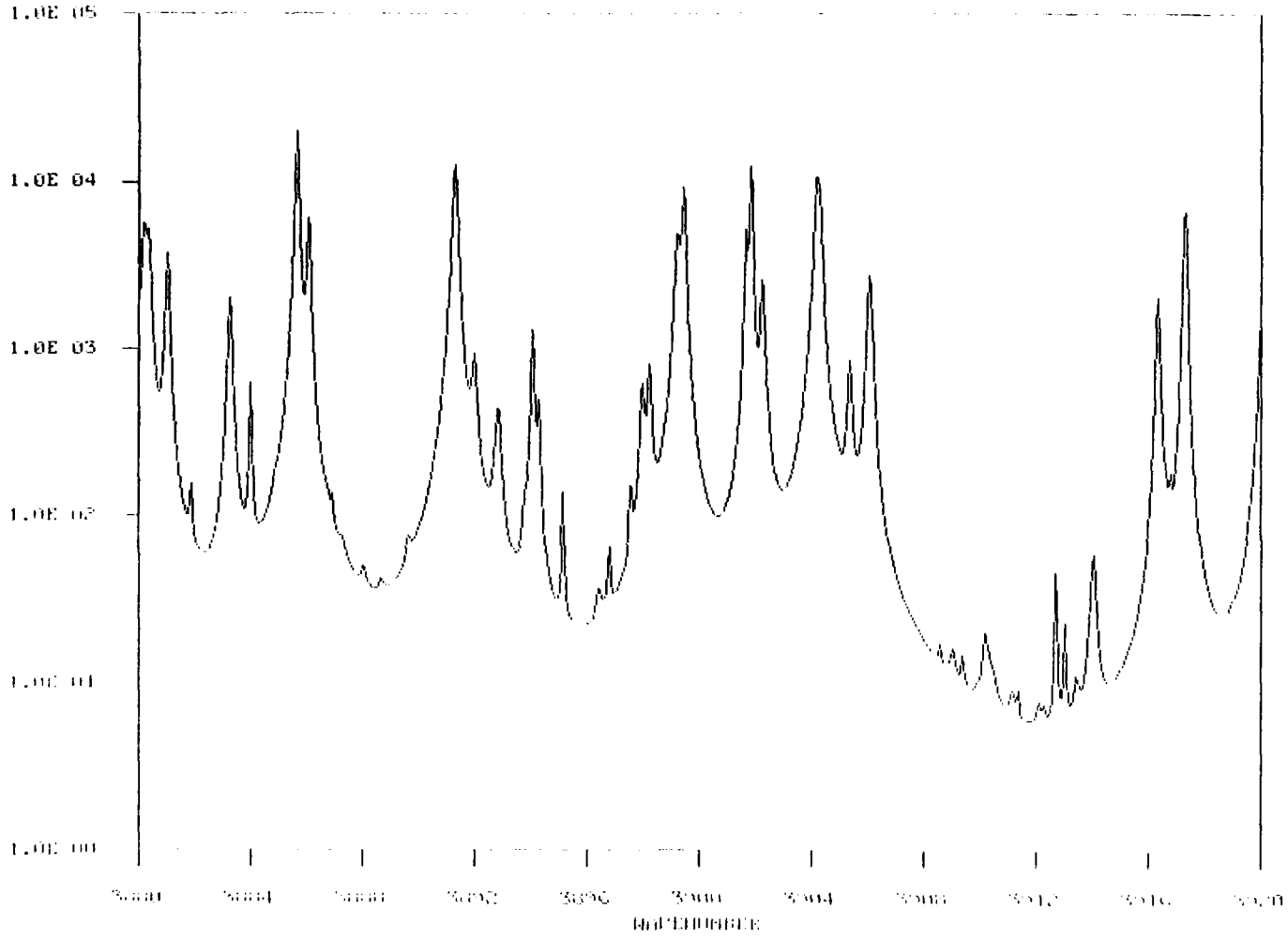

Fig. 50 — 3880-3920 cm^{-1} atmospheric absorption coefficient (km^{-1})

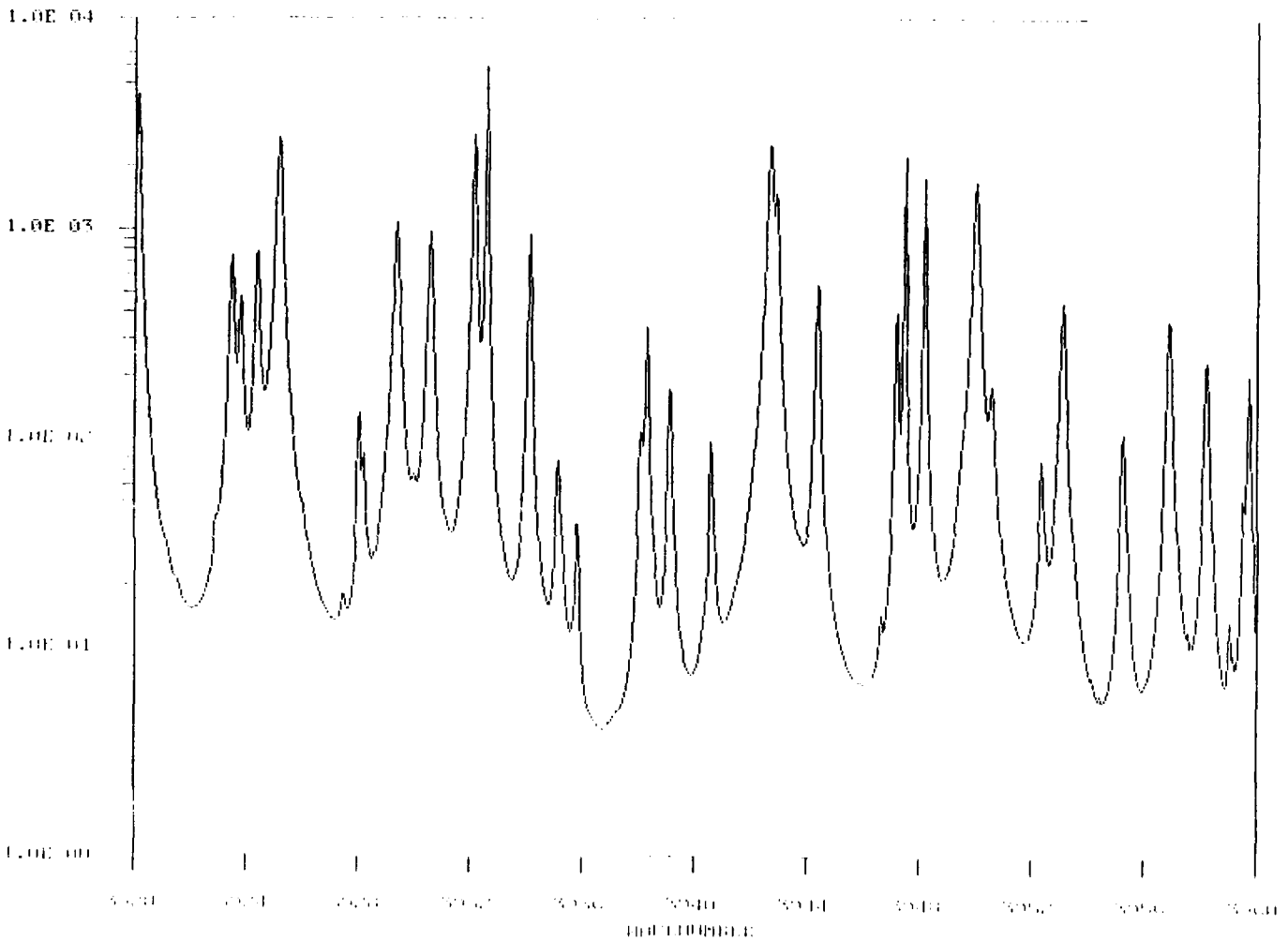

Fig. 51 — 3920-3960 cm^{-1} atmospheric absorption coefficient (km^{-1})

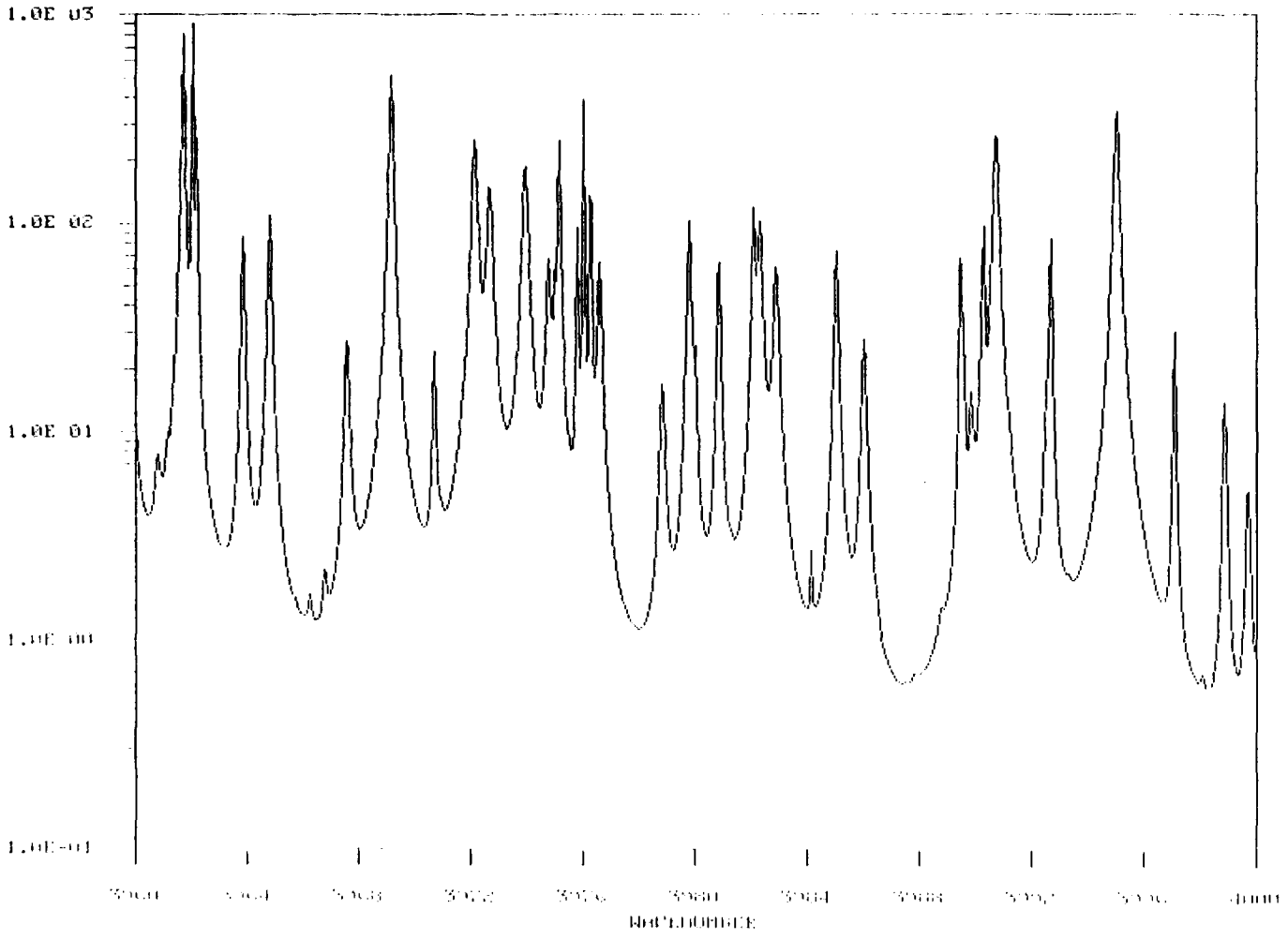

Fig. 52 — 3960-4000 cm^{-1} atmospheric absorption coefficient (km^{-1})

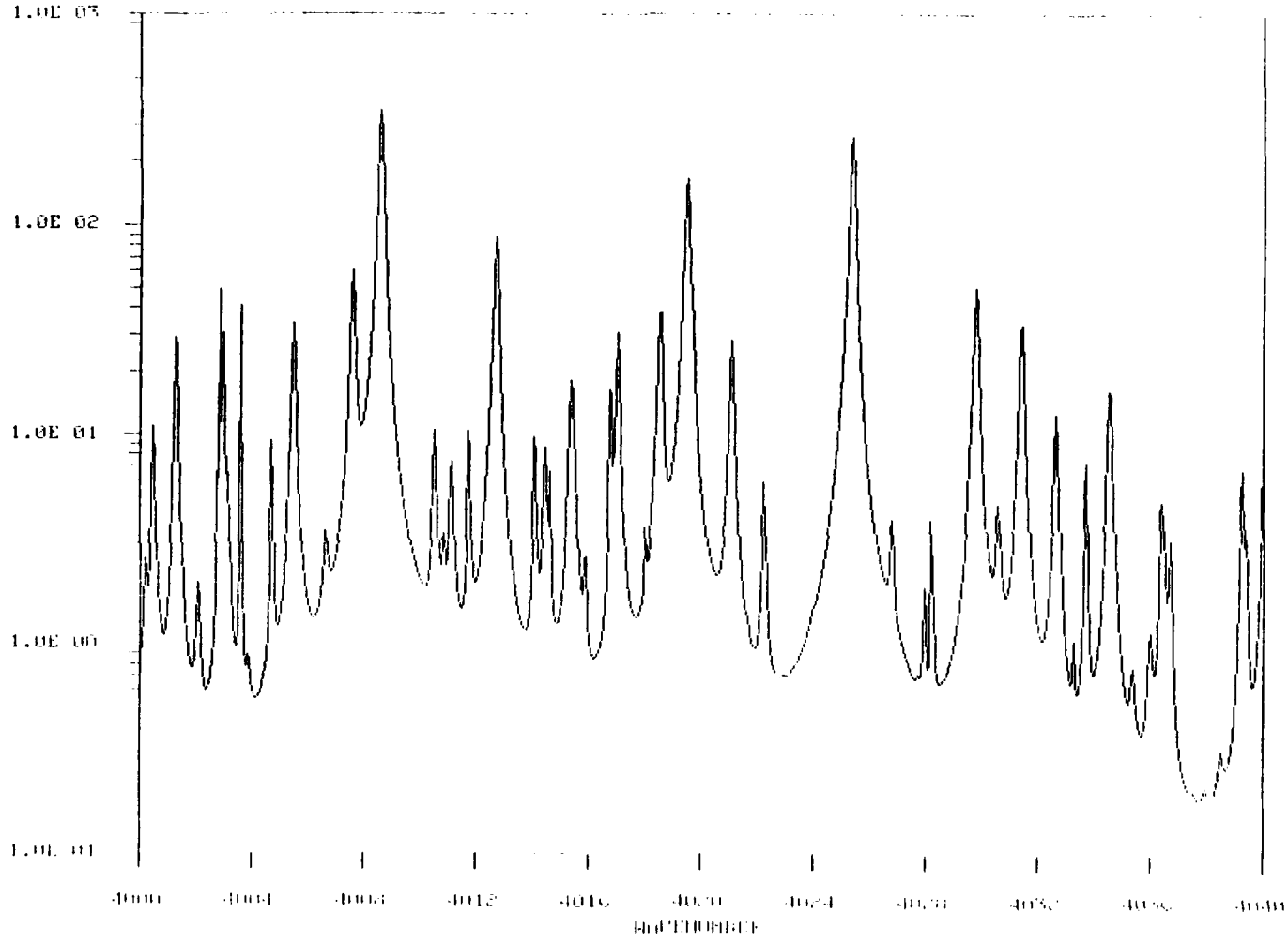

Fig. 53 — 4000-4040 cm^{-1} atmospheric absorption coefficient (km^{-1})

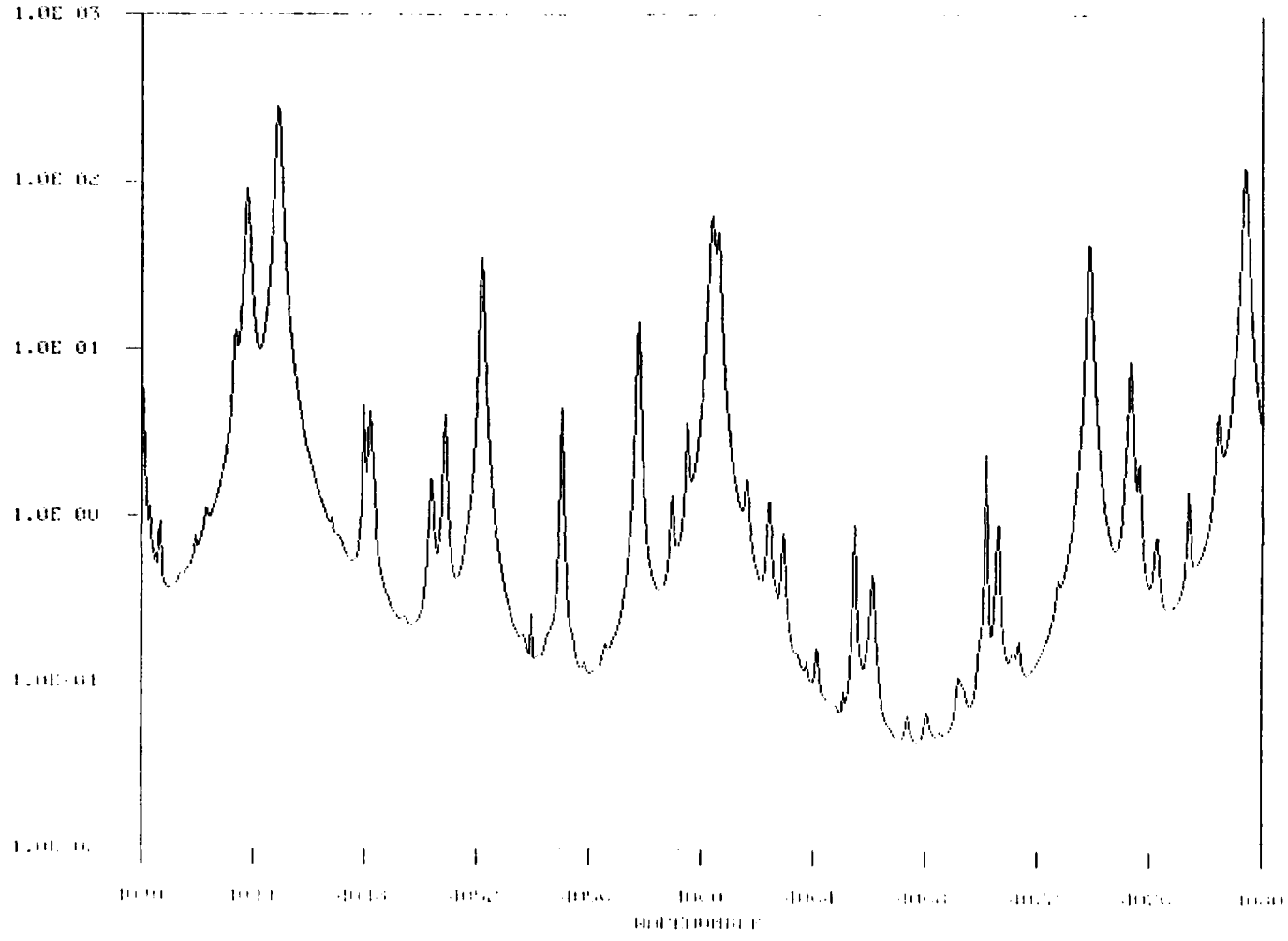

Fig. 54 — 4040-4080 cm^{-1} atmospheric absorption coefficient (km^{-1})

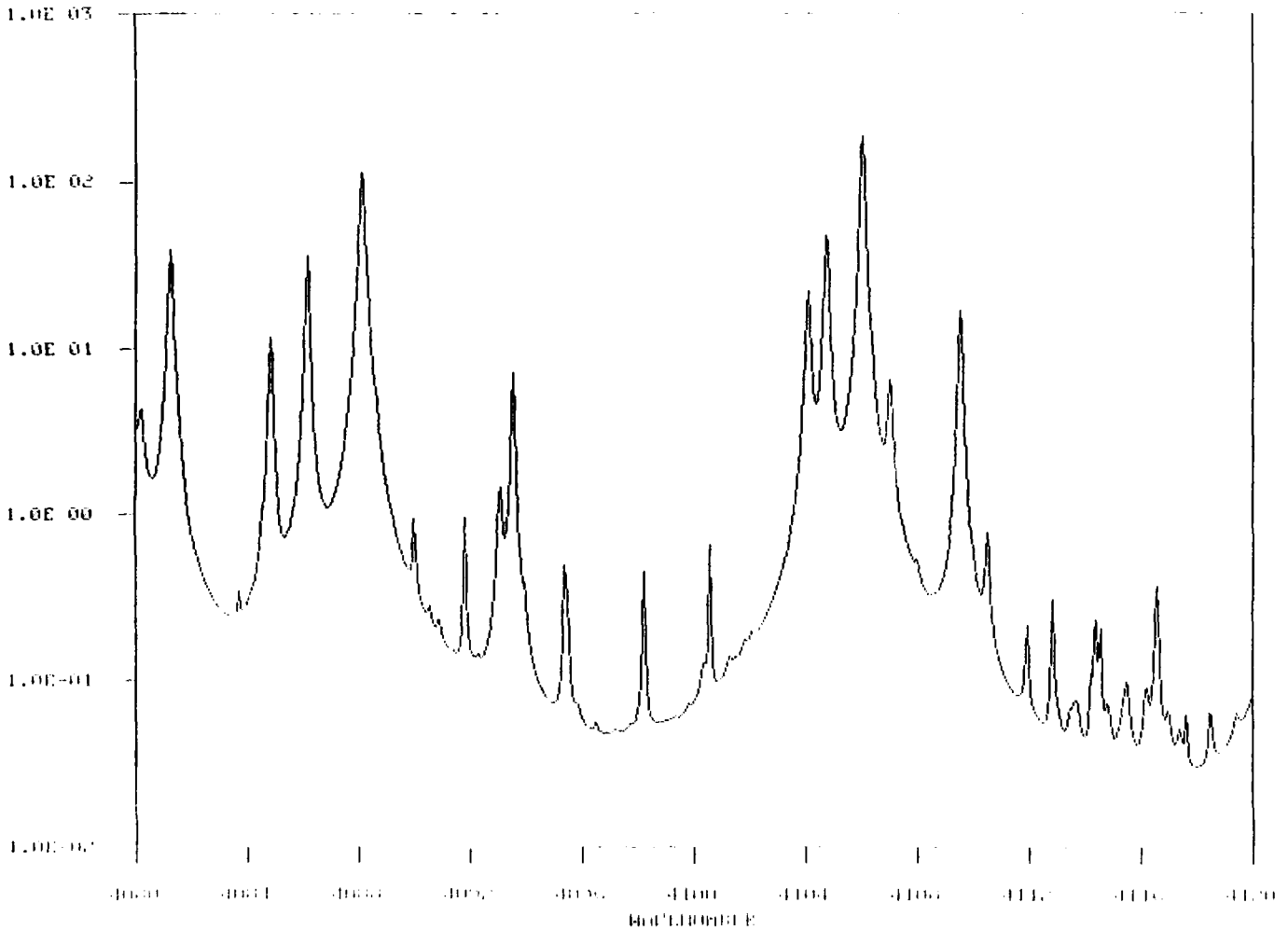

Fig. 55 — 4080-4120 cm $^{-1}$ atmospheric absorption coefficient (km^{-1})

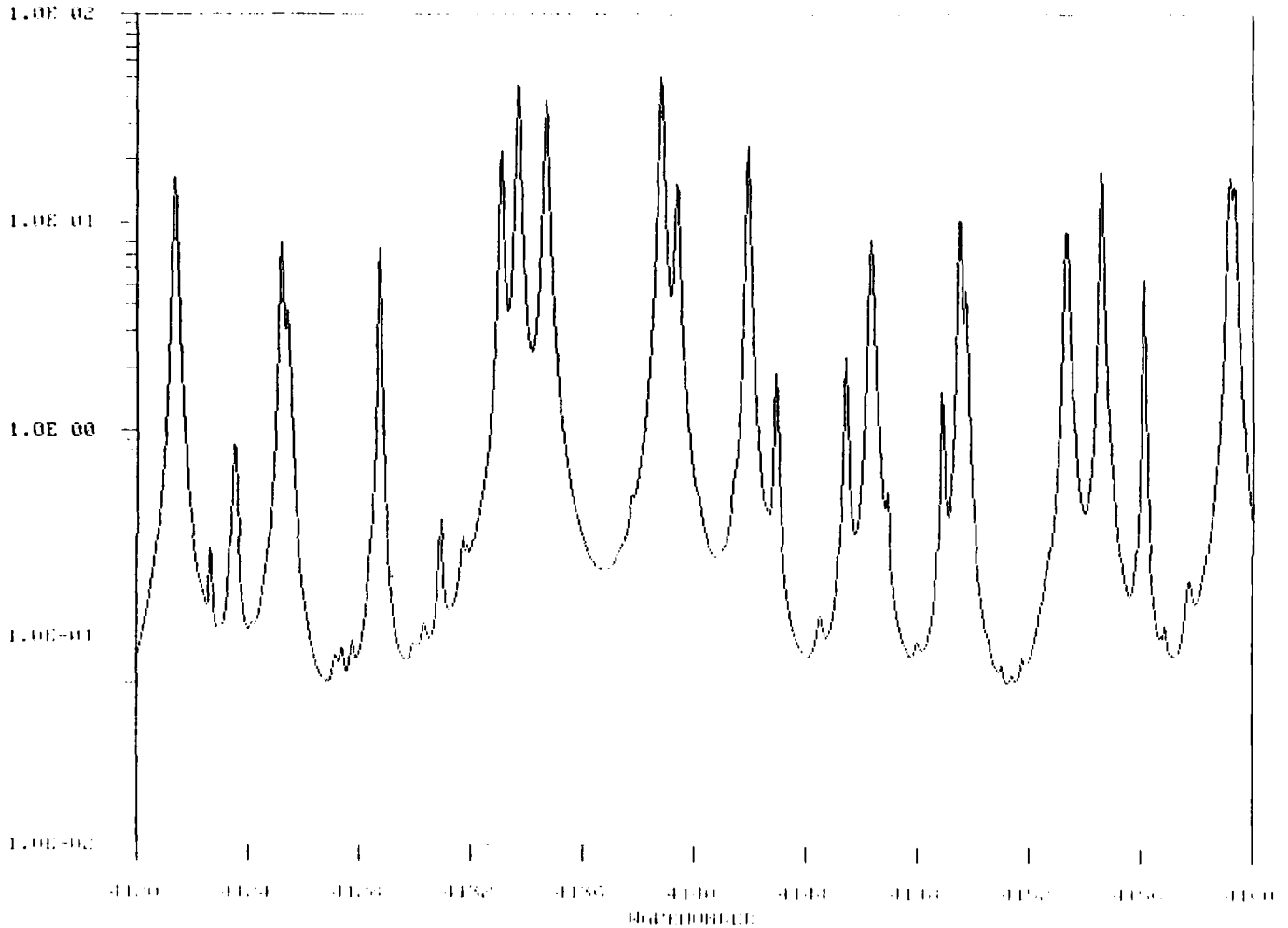

Fig. 56 — 4120-4160 cm^{-1} atmospheric absorption coefficient (km^{-1})

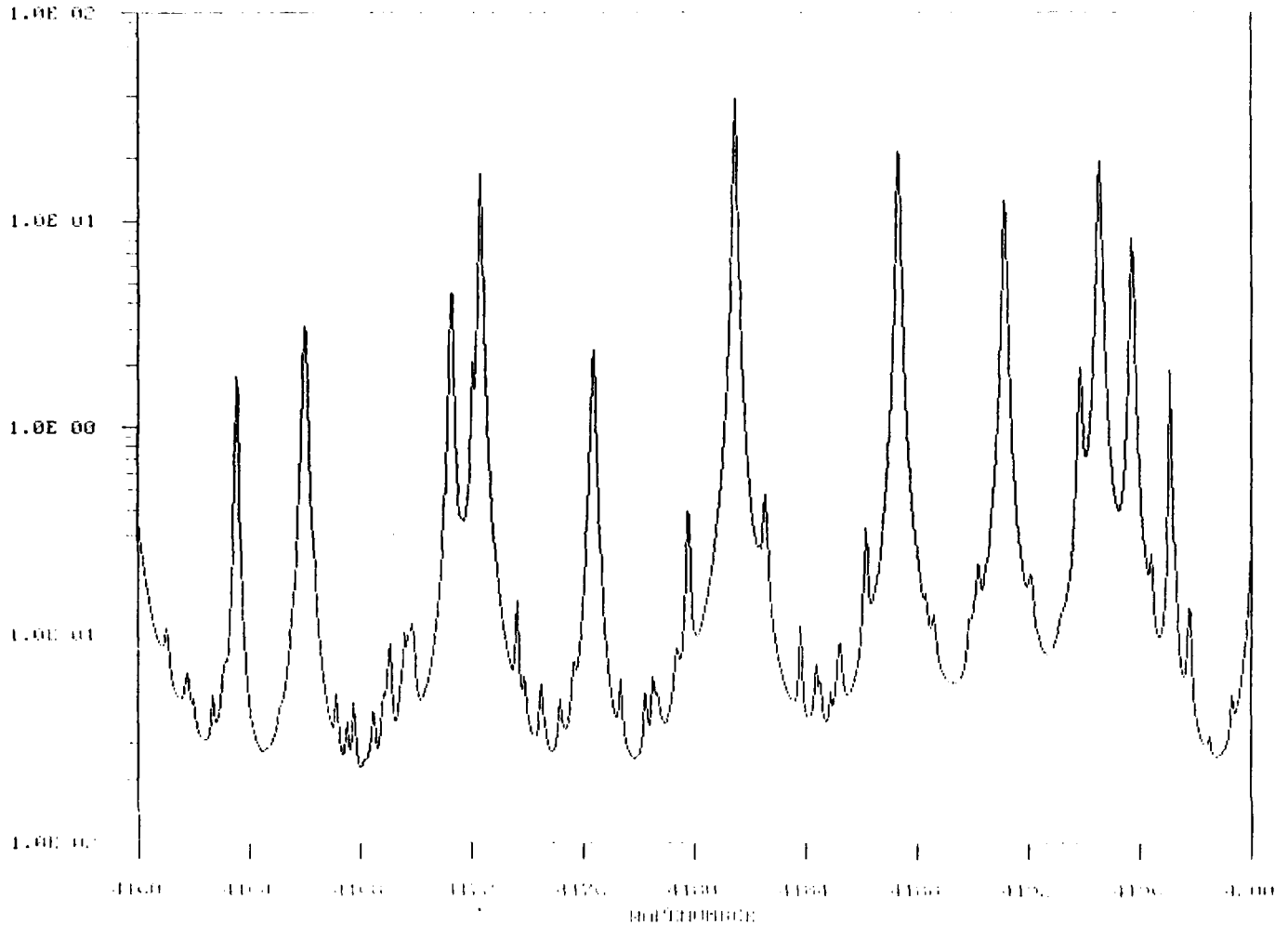

Fig. 57 — 4160-4200 cm^{-1} atmospheric absorption coefficient (km^{-1})

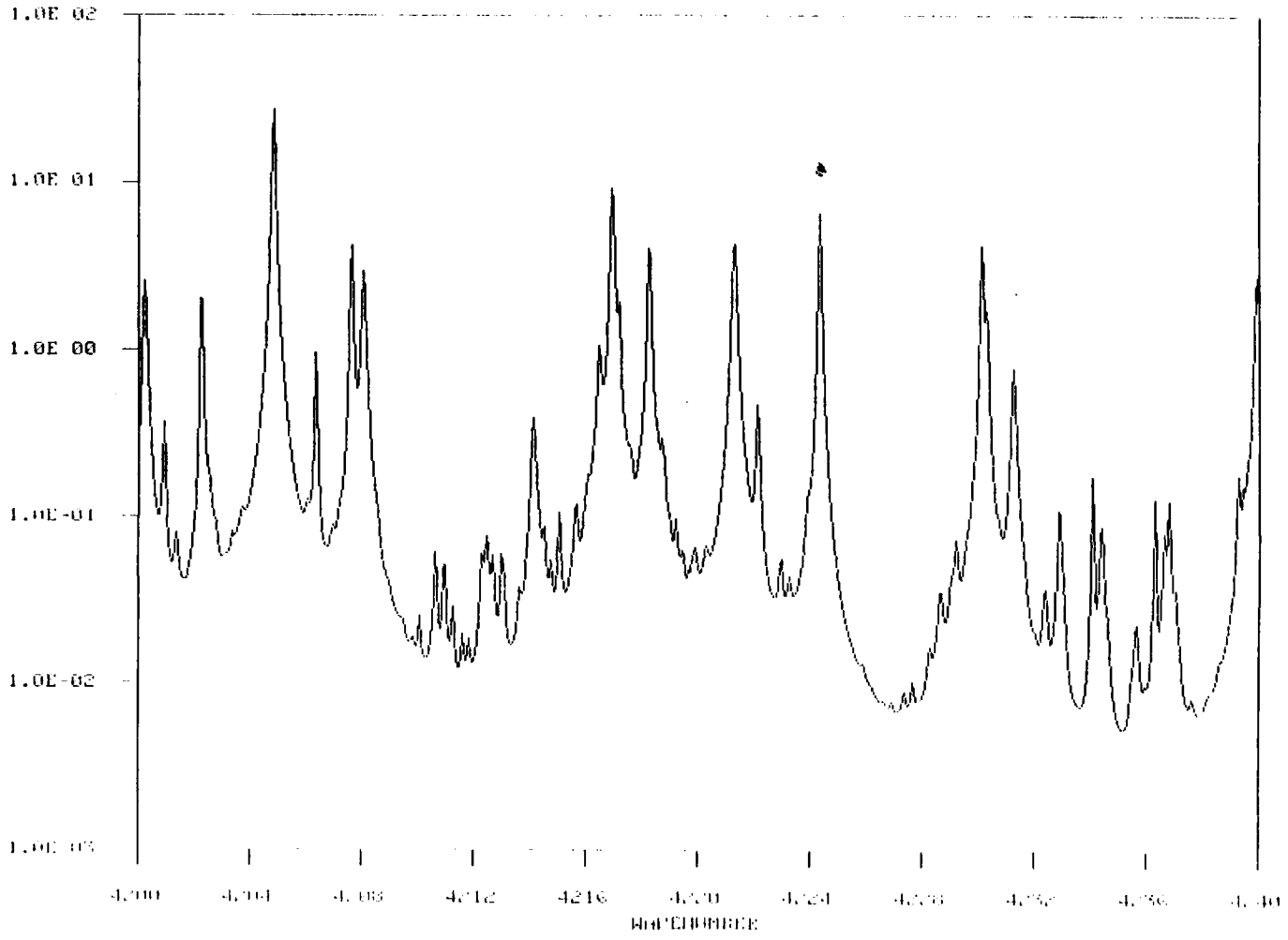

Fig. 58 — 4200-4240 cm^{-1} atmospheric absorption coefficient (km^{-1})

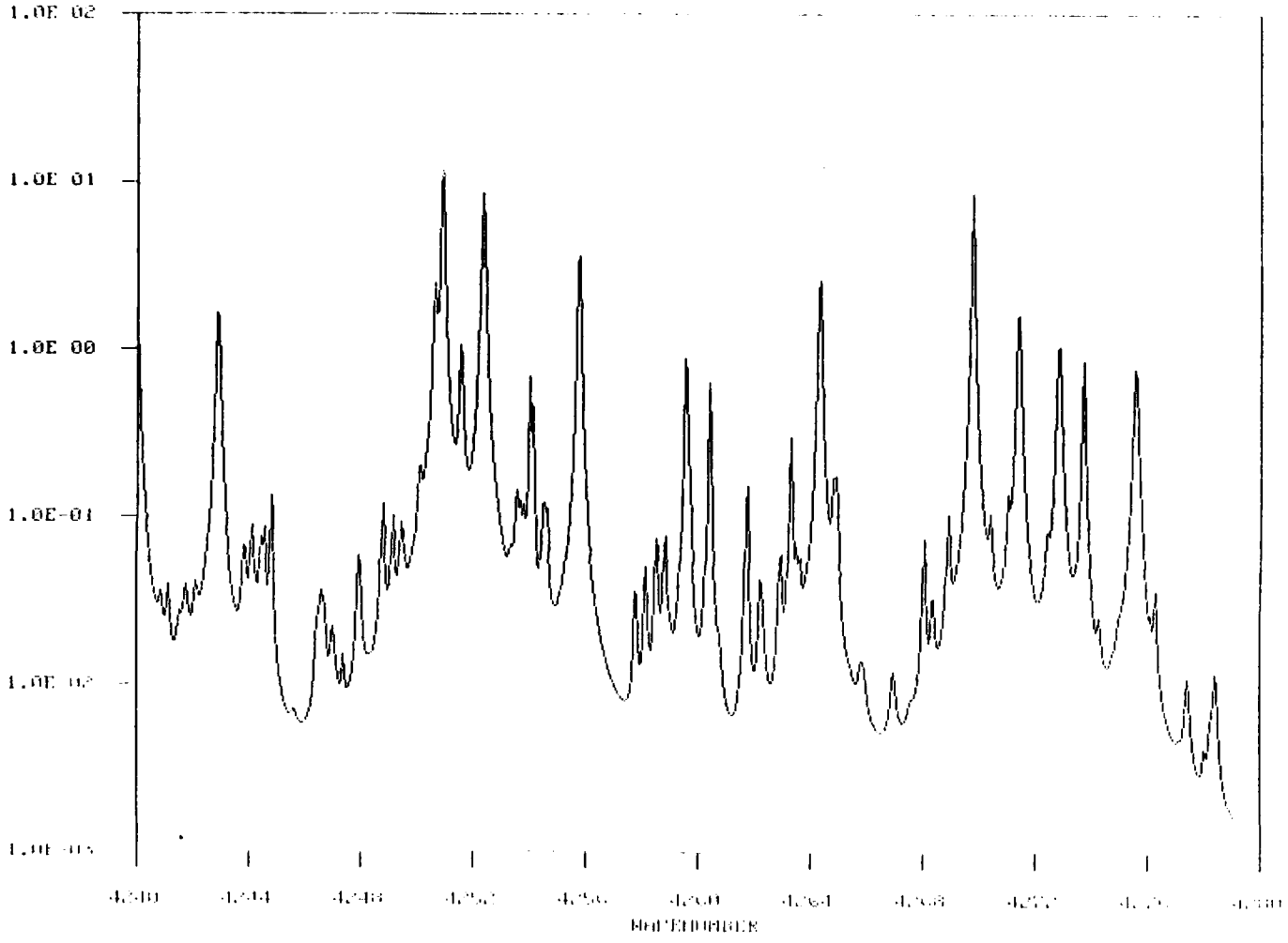

Fig. 59 — 4240-4280 cm^{-1} atmospheric absorption coefficient (km^{-1})

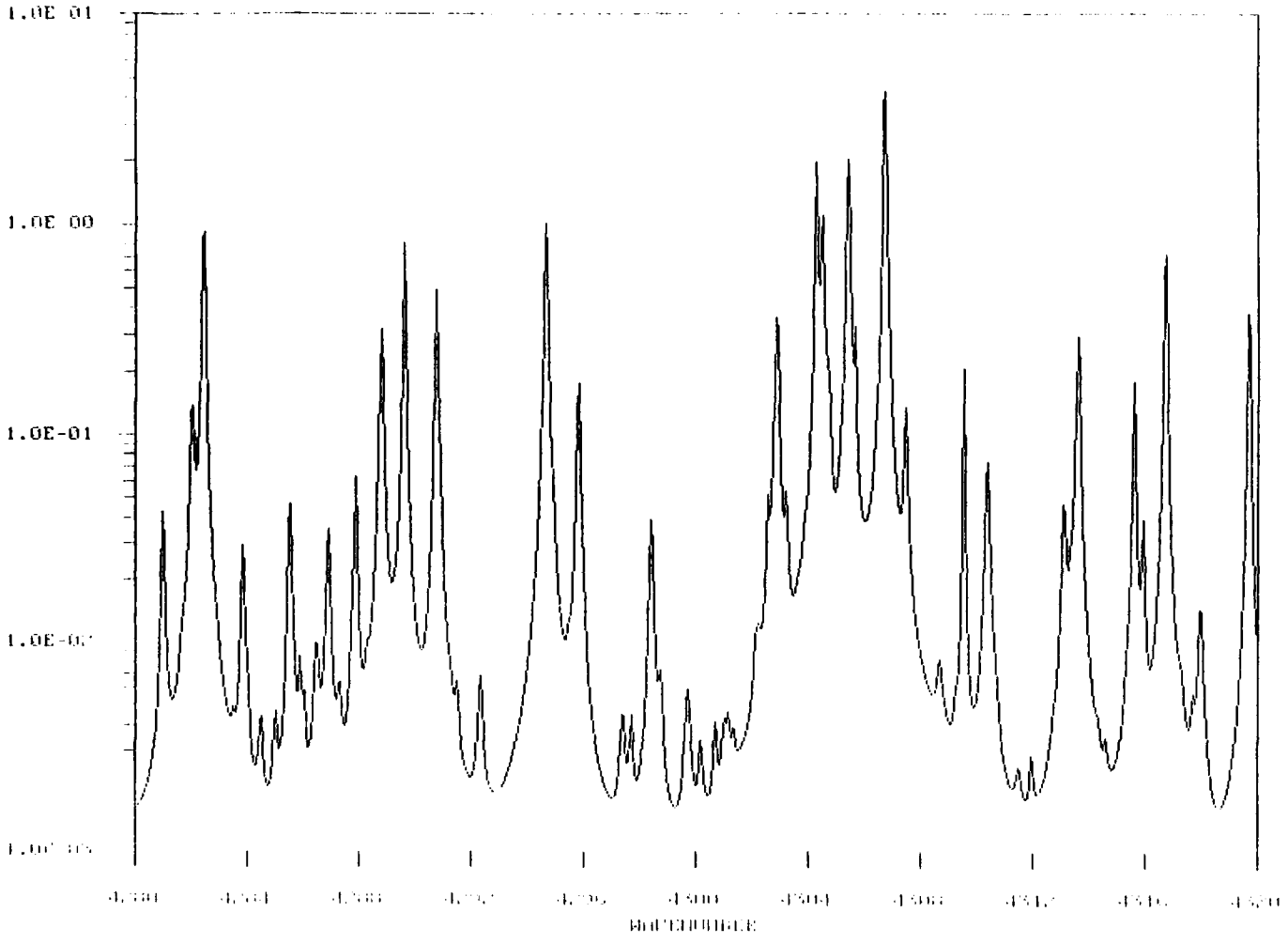

Fig. 60 — 4280-4320 cm^{-1} atmospheric absorption coefficient (km^{-1})

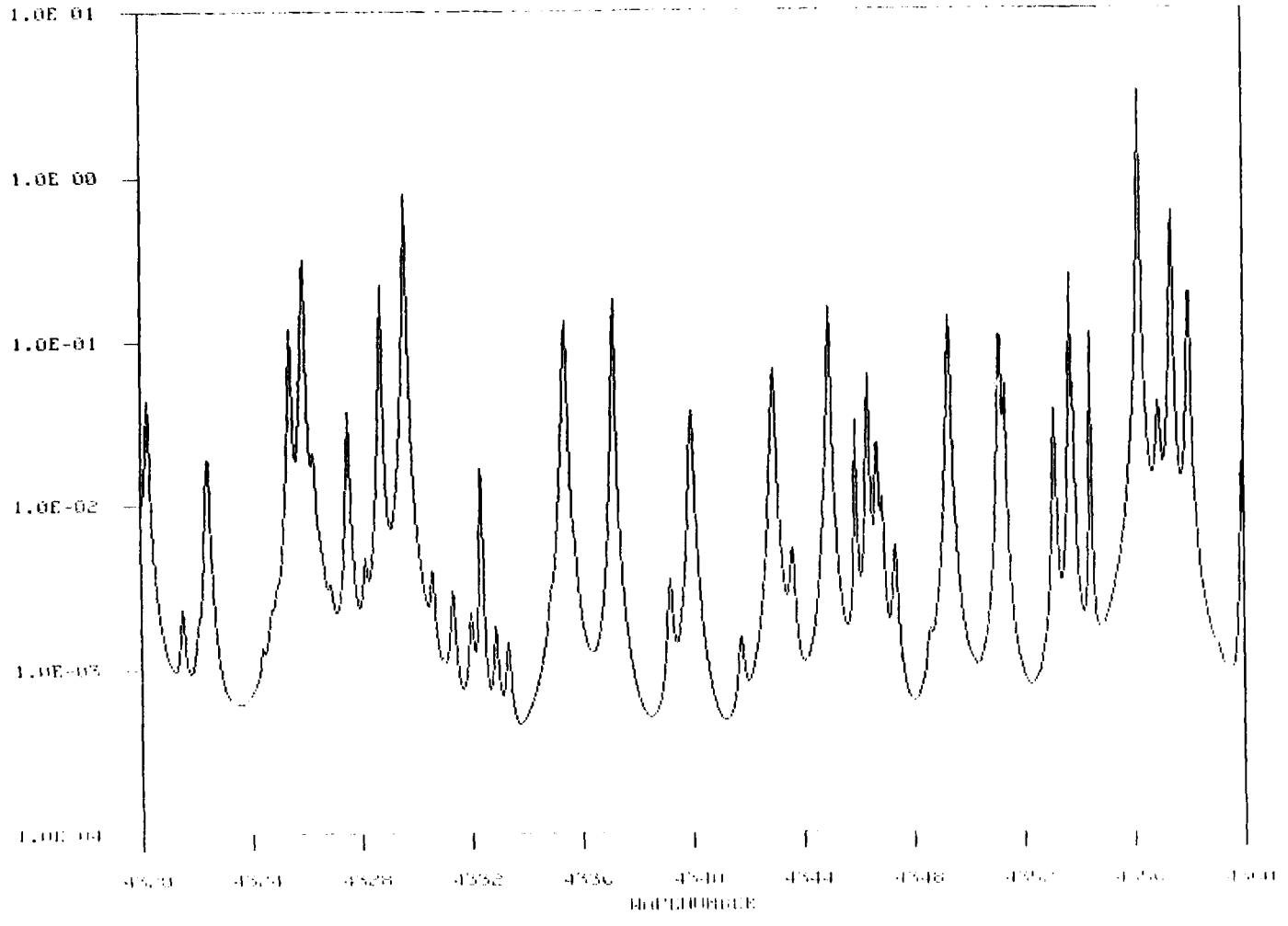

Fig. 61 — 4320-4360 cm^{-1} atmospheric absorption coefficient (km^{-1})

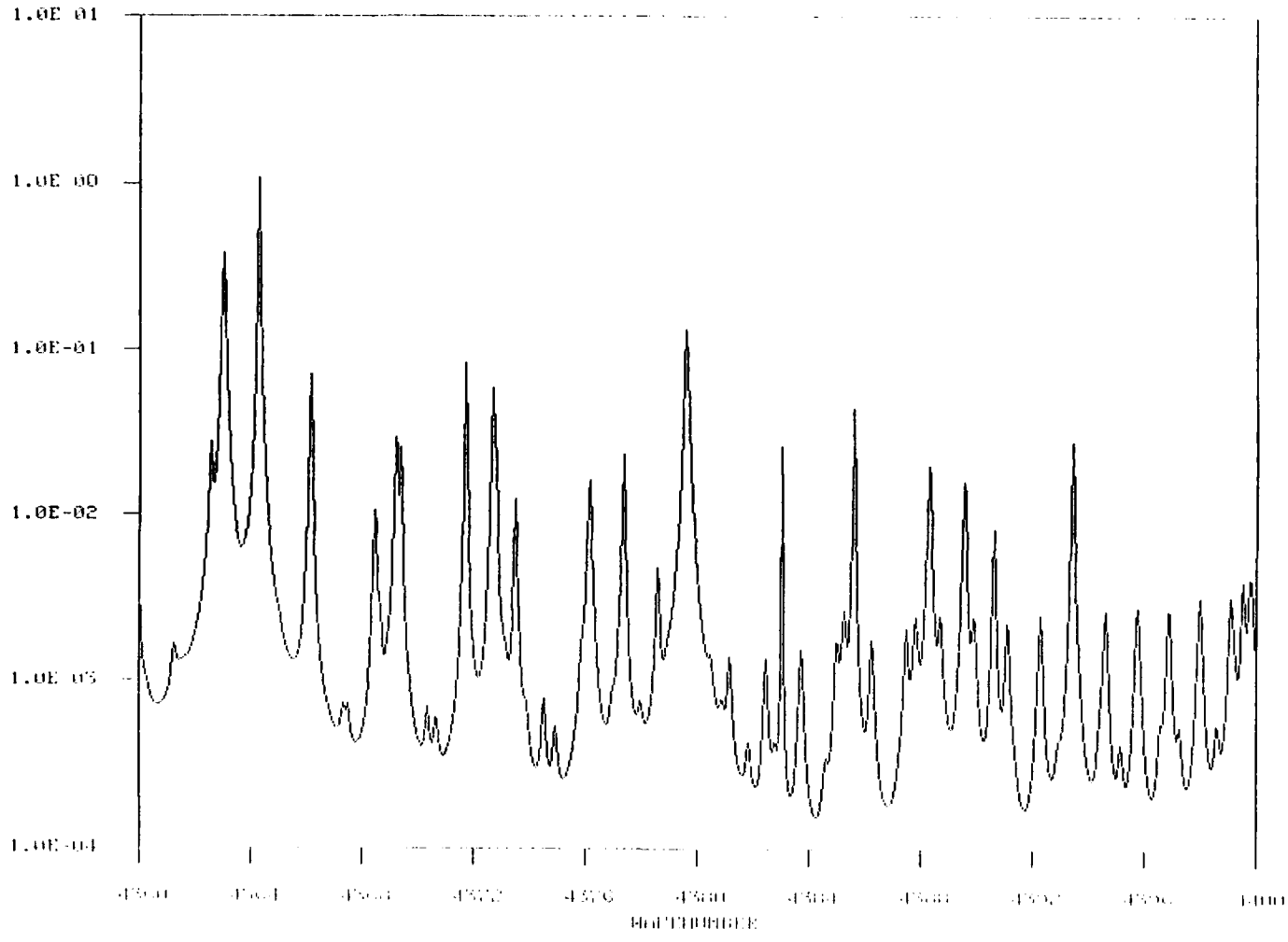

Fig. 62 — 4360-4400 cm^{-1} atmospheric absorption coefficient (km^{-1})

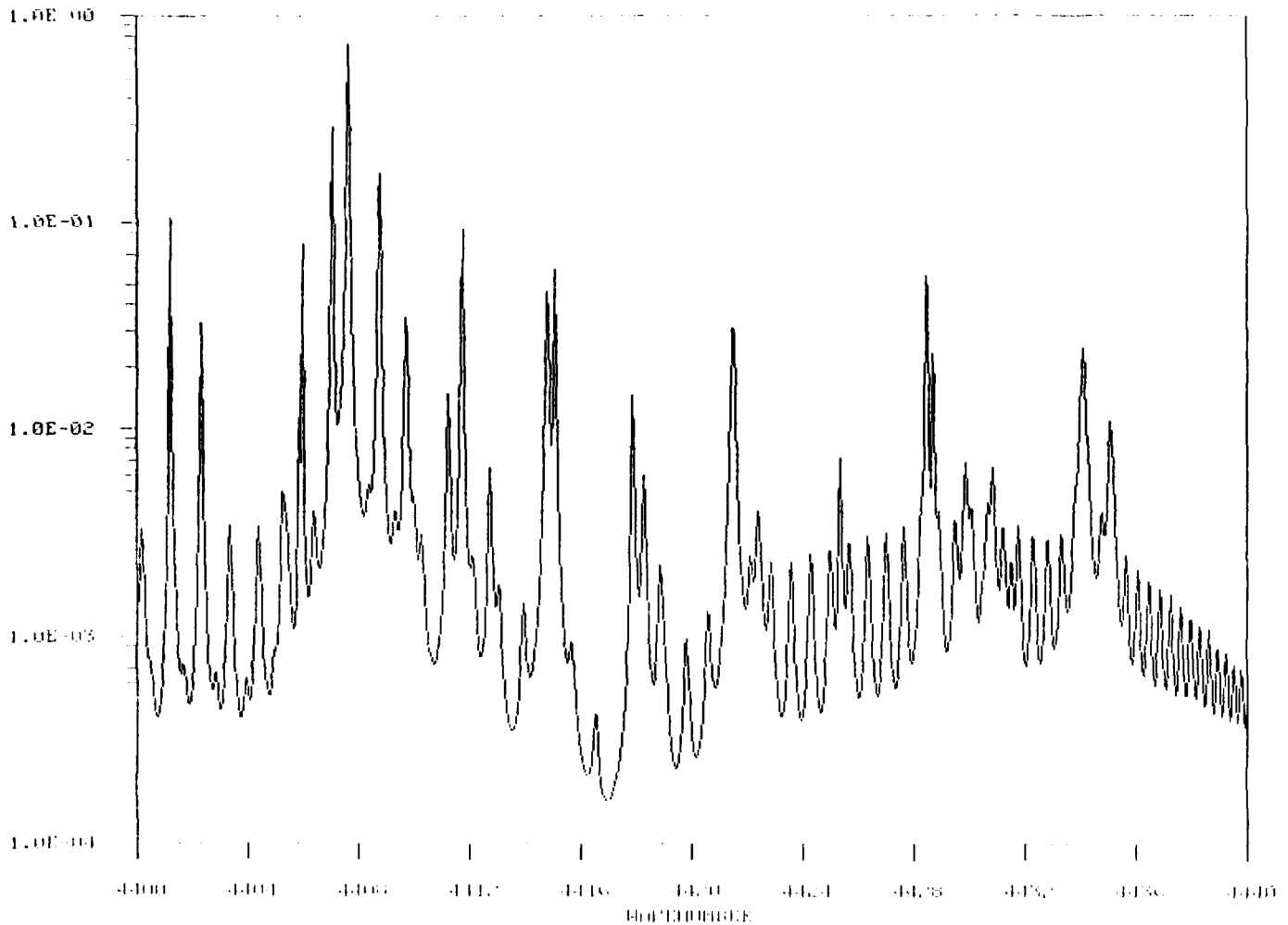

Fig. 63 — 4400-4440 cm^{-1} atmospheric absorption coefficient (km^{-1})

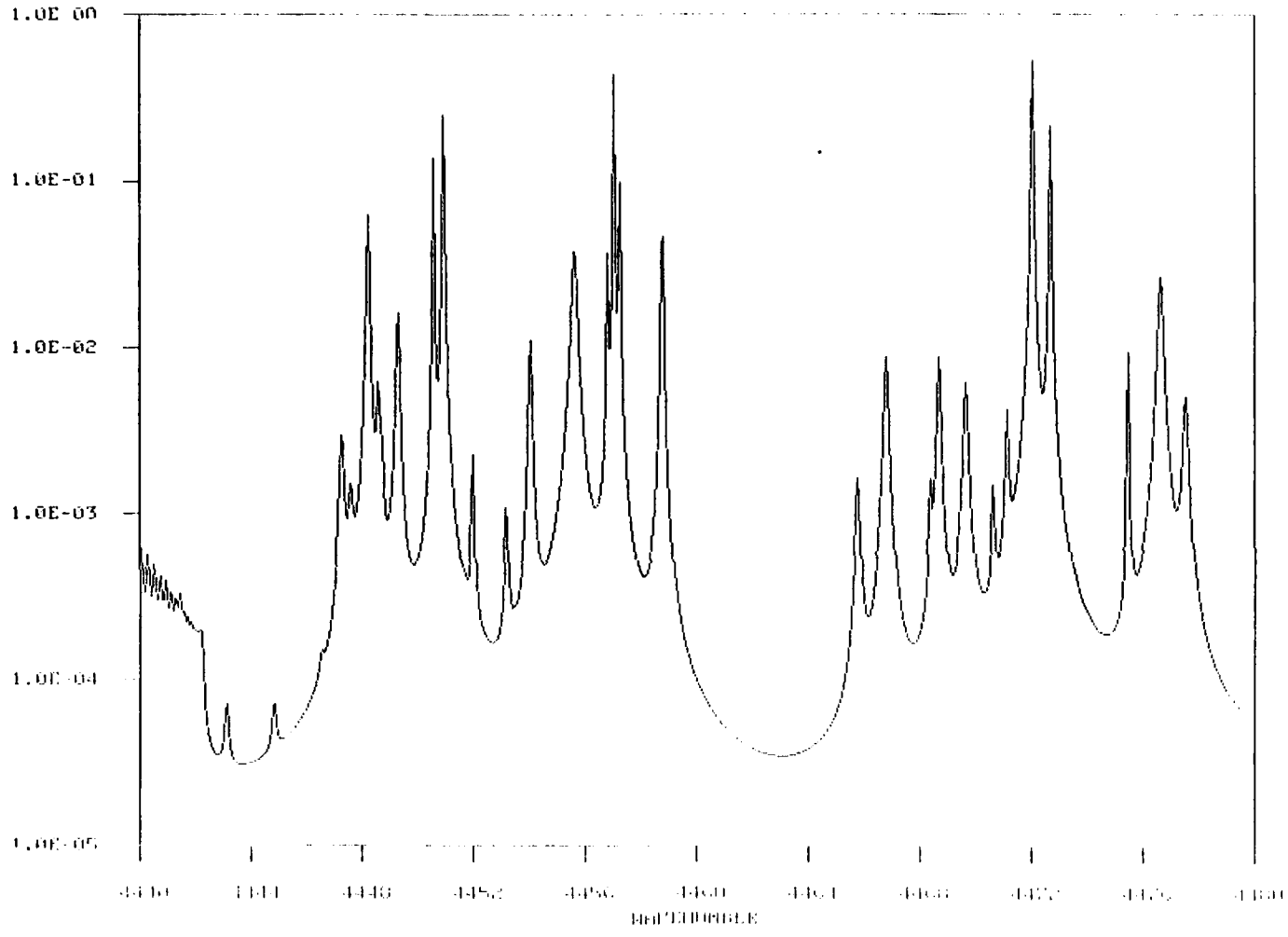

Fig. 64 — 4440-4480 cm^{-1} atmospheric absorption coefficient (km^{-1})

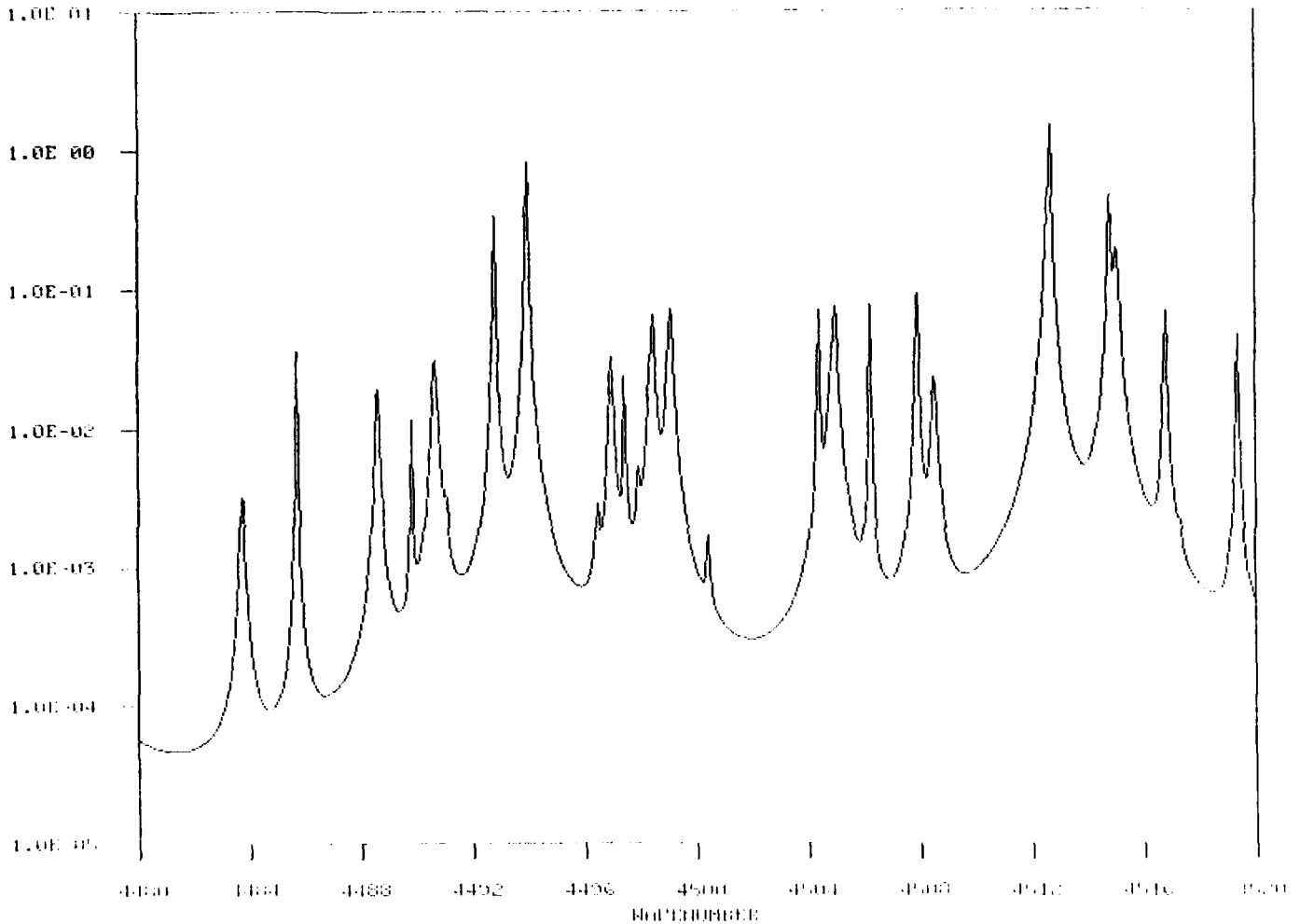

Fig. 65 — 4480-4520 cm^{-1} atmospheric absorption coefficient (km^{-1})

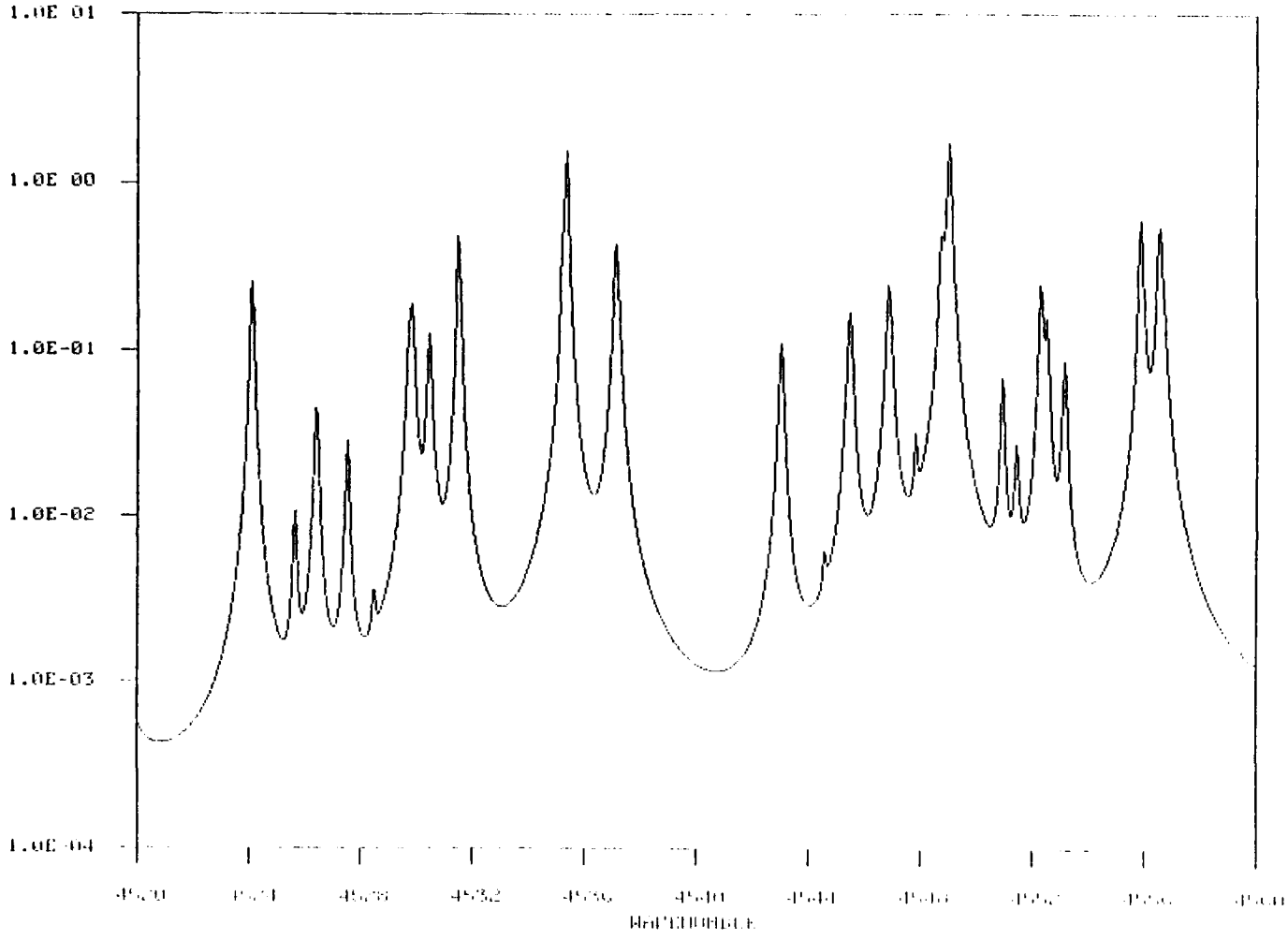

Fig. 66 — 4520-4560 cm^{-1} atmospheric absorption coefficient (km^{-1})

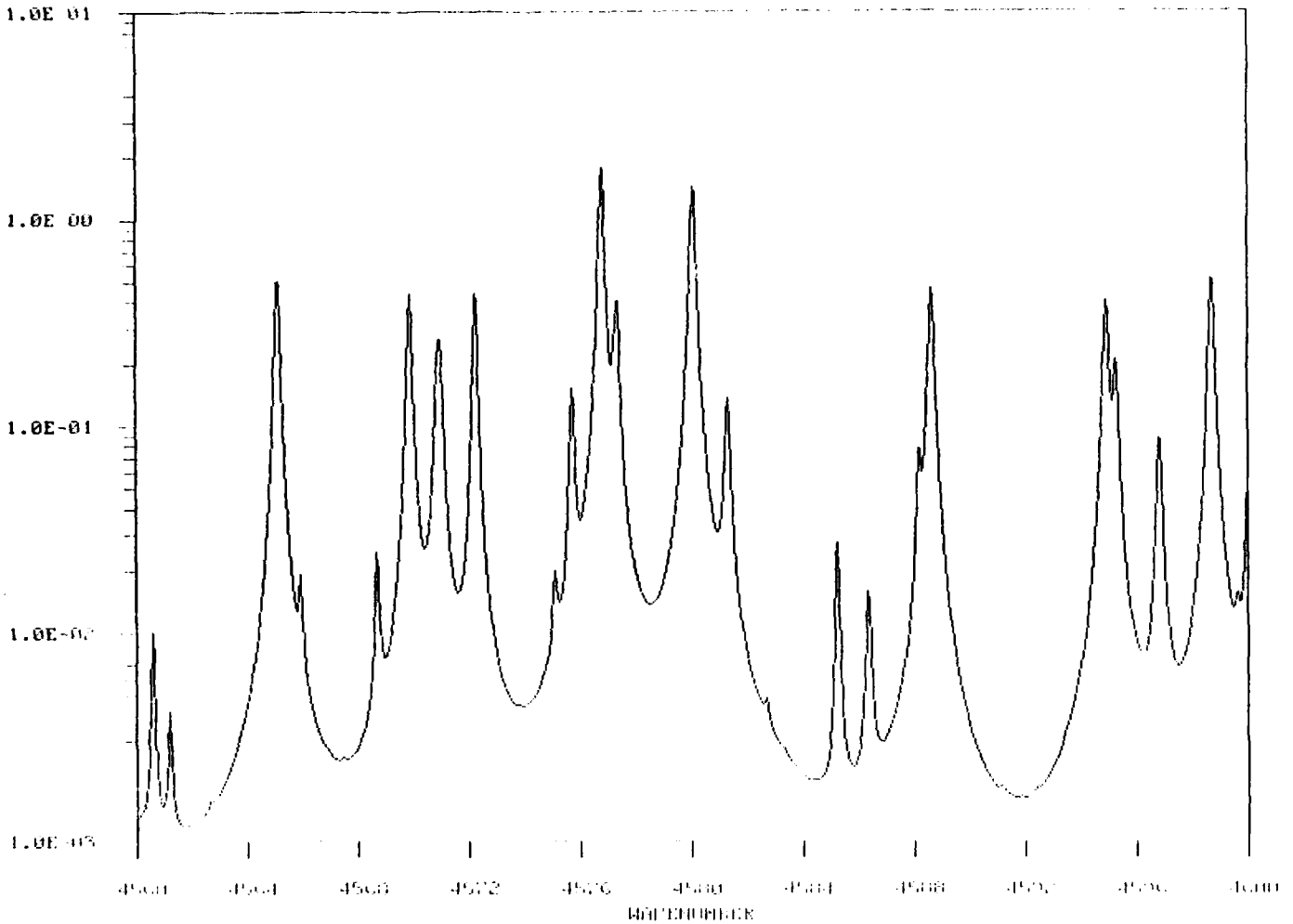

Fig. 67 — 4560-4600 cm^{-1} atmospheric absorption coefficient (km^{-1})

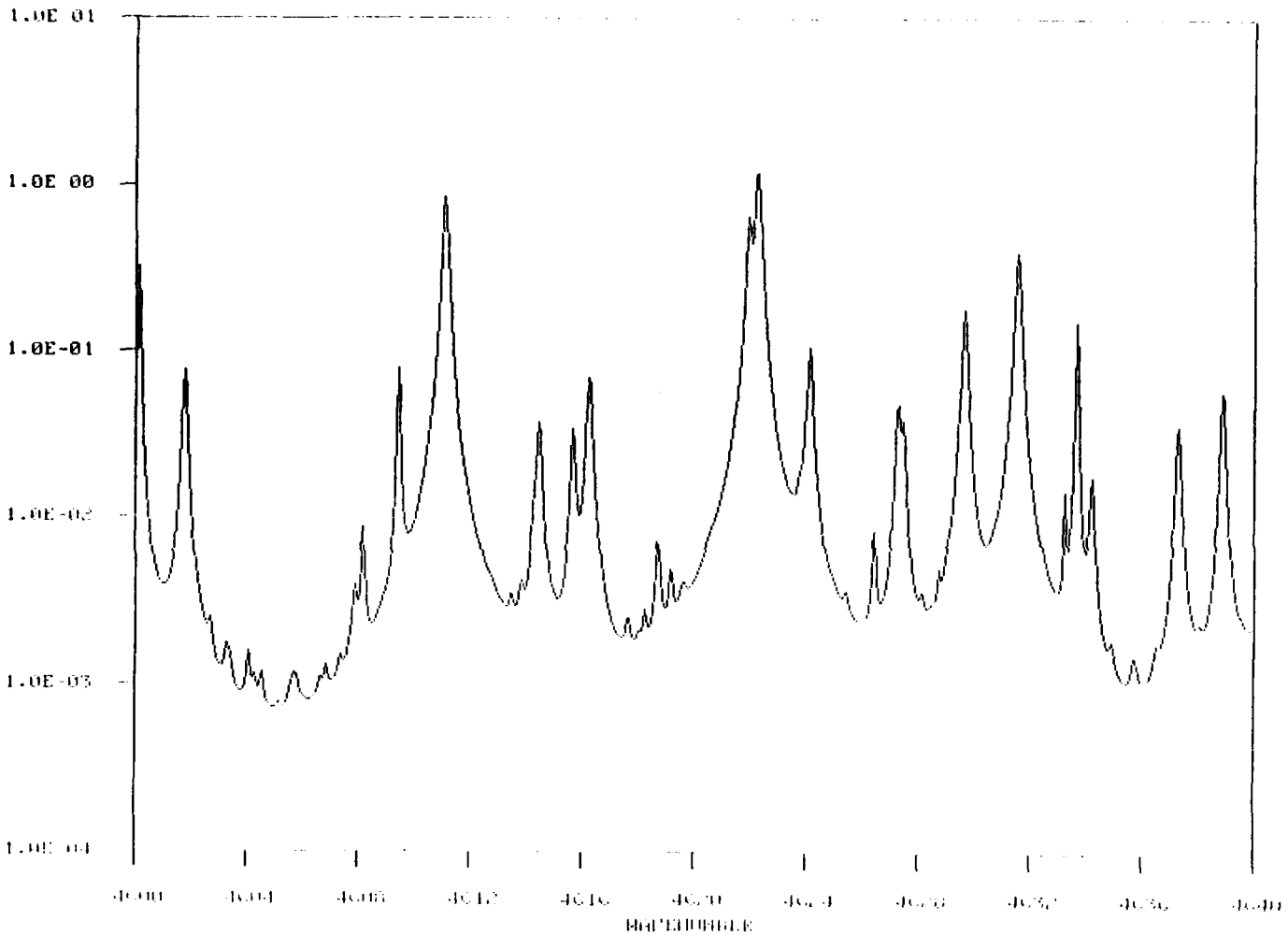

Fig. 68 — 4600-4640 cm^{-1} atmospheric absorption coefficient (km^{-1})

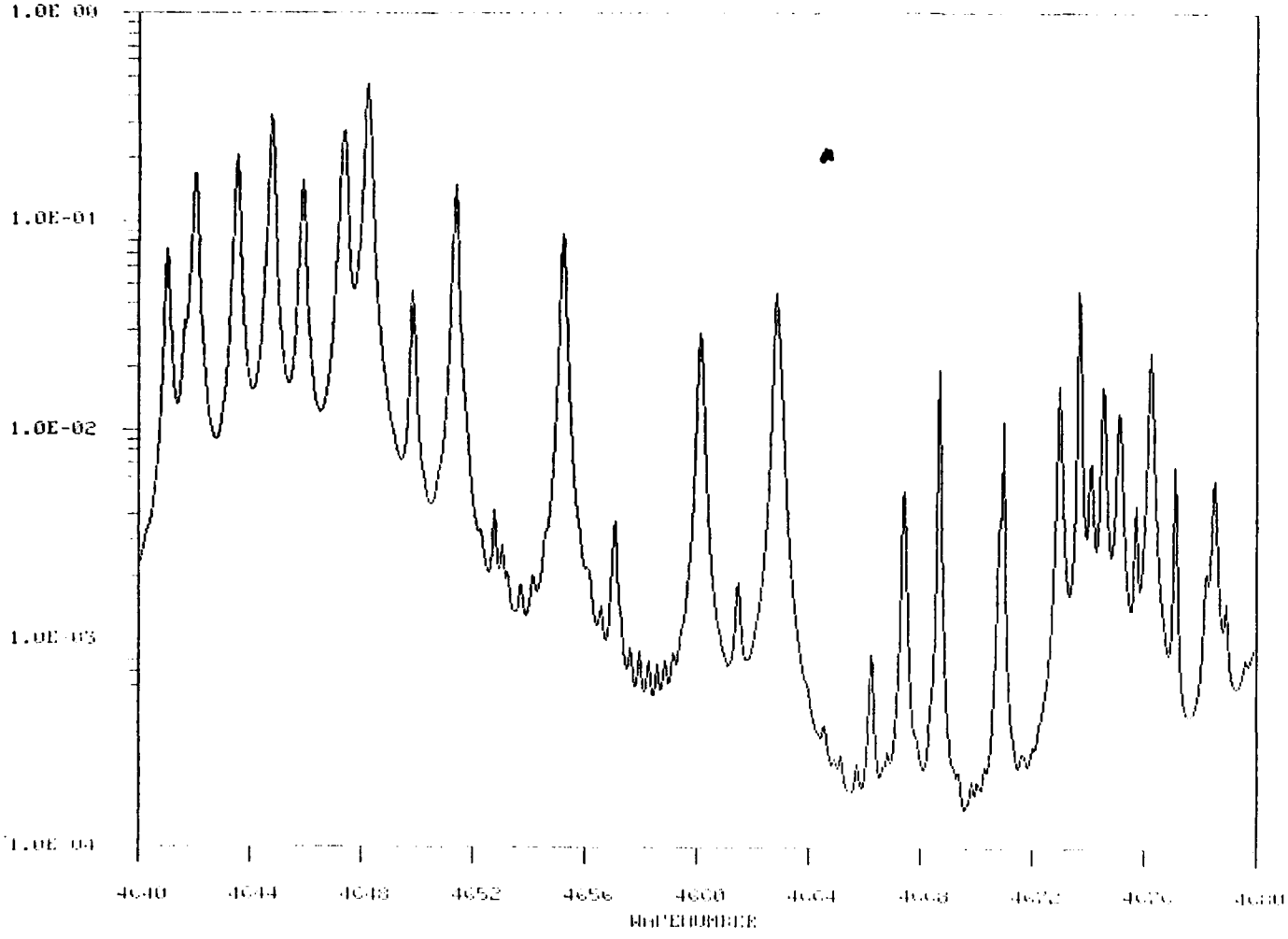

Fig. 69 — 4640-4680 cm^{-1} atmospheric absorption coefficient (km^{-1})

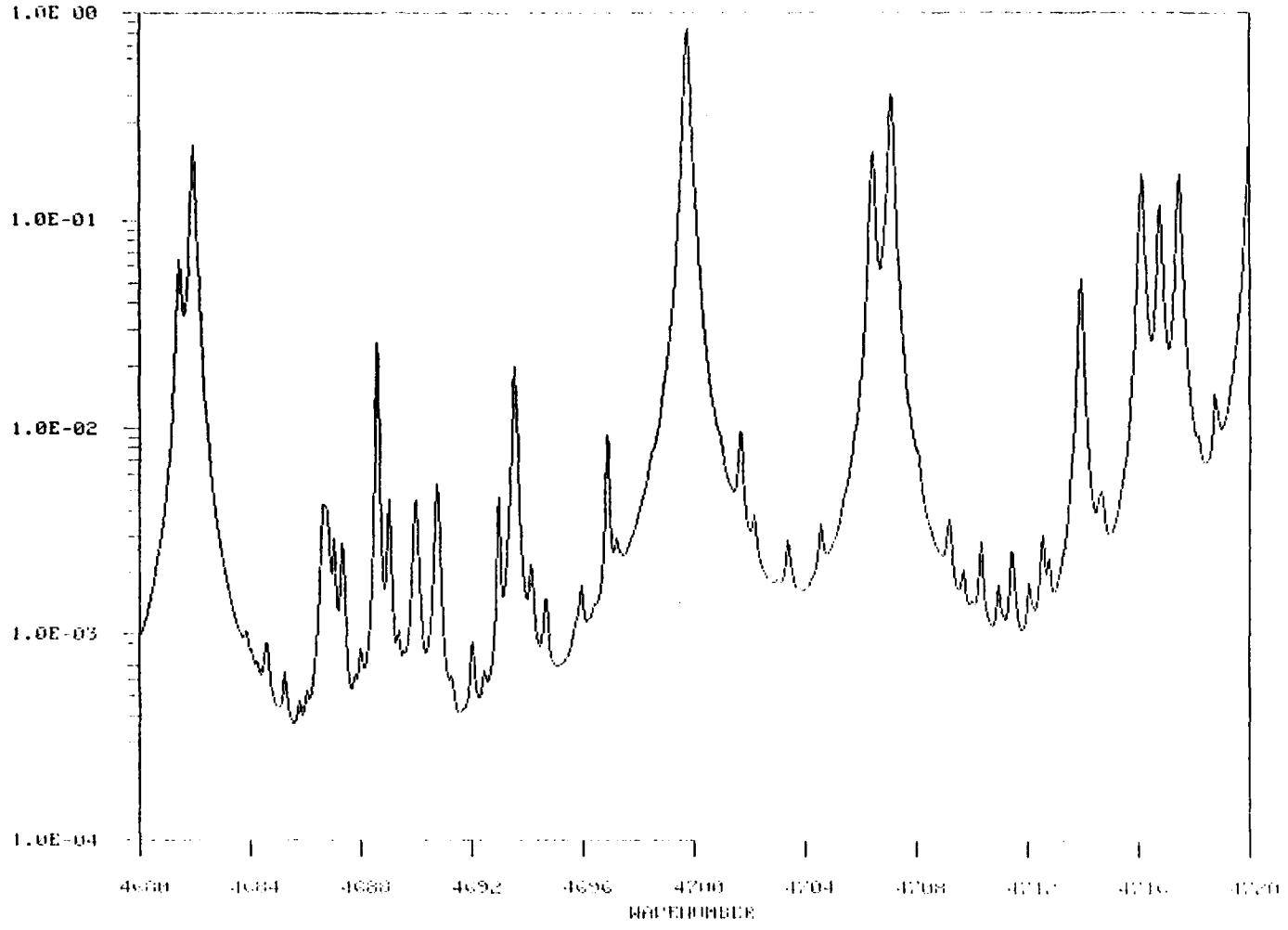

Fig. 70 — 4680-4720 cm^{-1} atmospheric absorption coefficient (km^{-1})

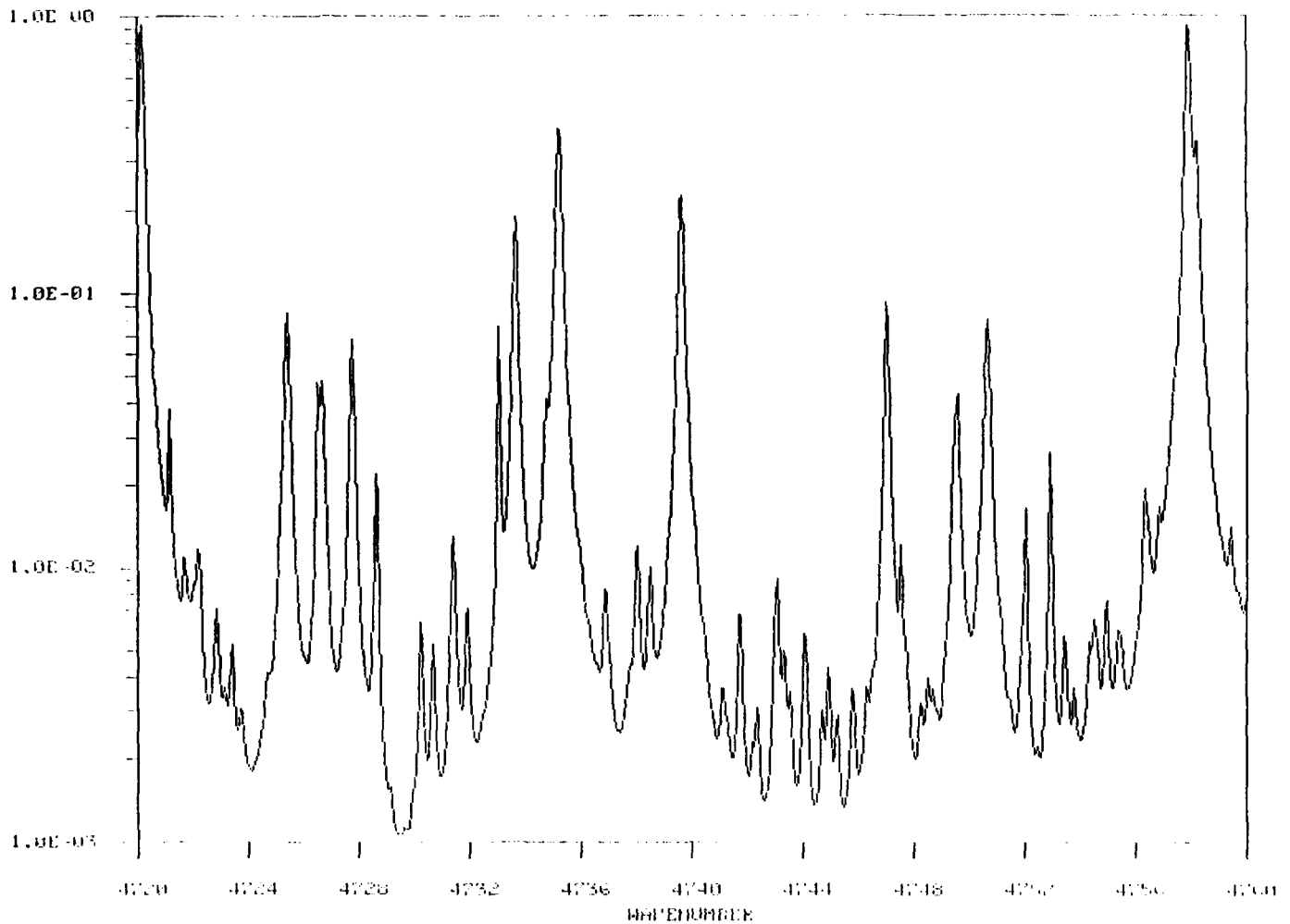

Fig. 71 — 4720-4760 cm^{-1} atmospheric absorption coefficient (km^{-1})

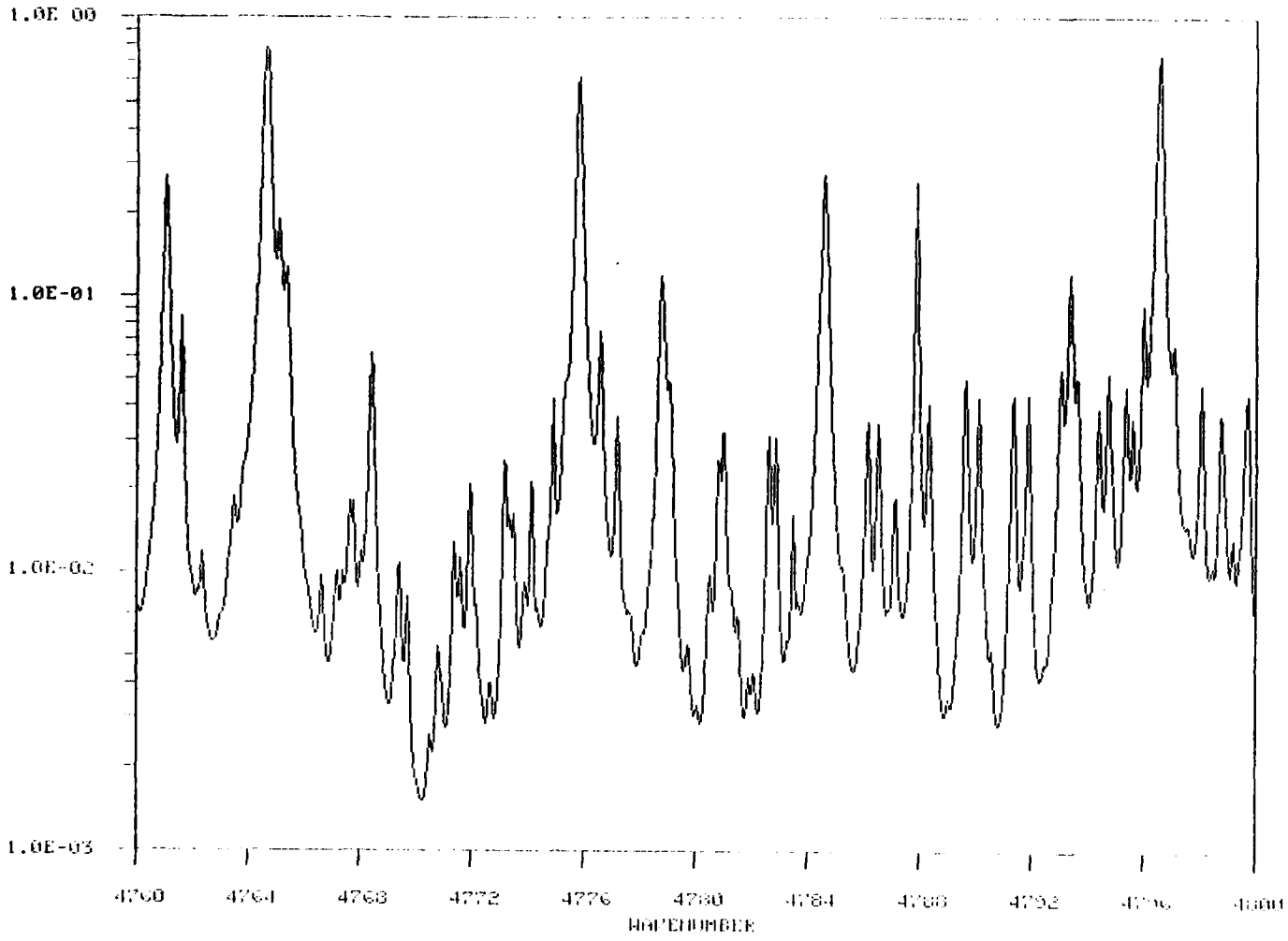

Fig. 72 — 4760-4800 cm^{-1} atmospheric absorption coefficient (km^{-1})

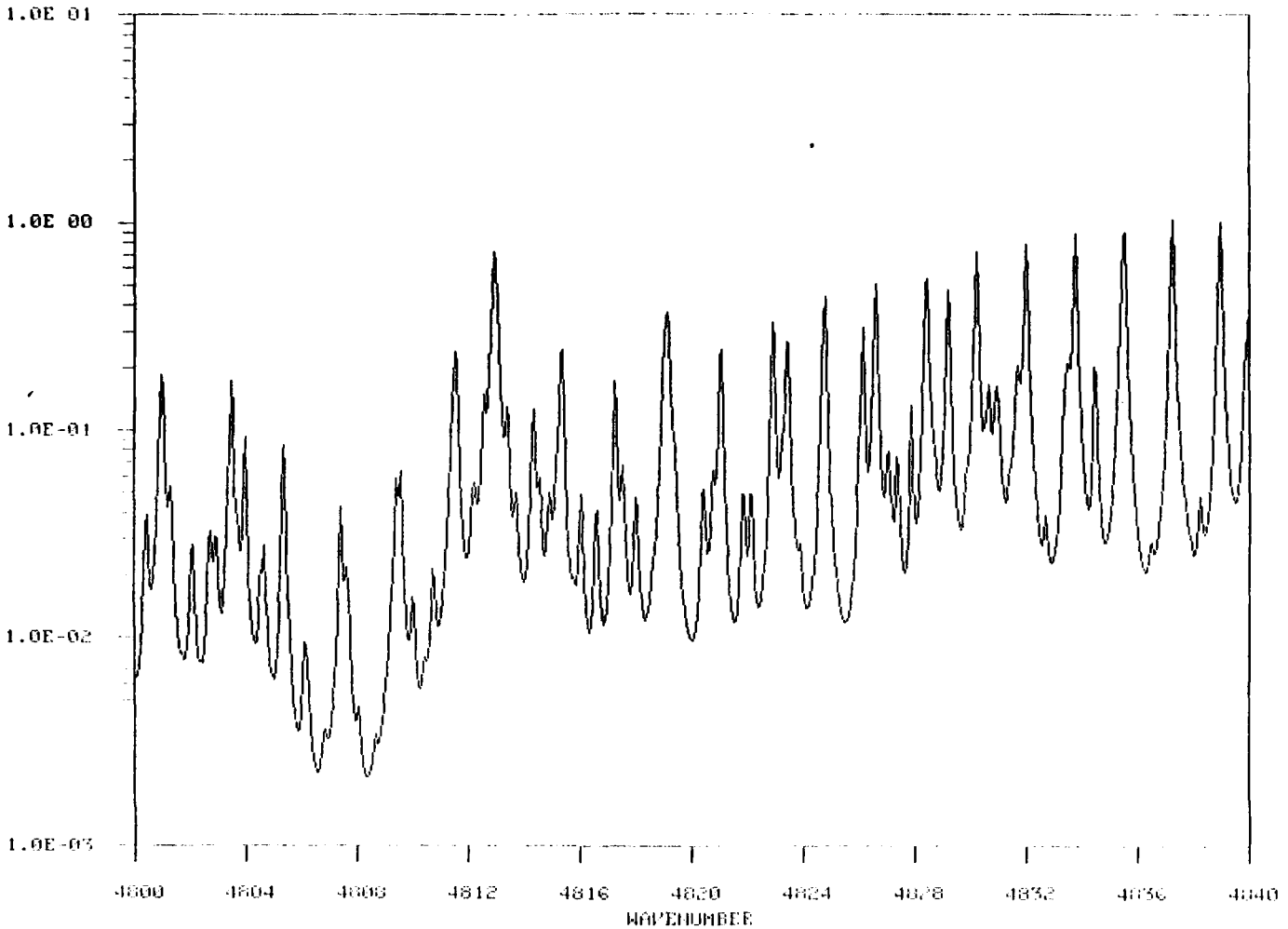

Fig. 73 — 4800-4840 cm^{-1} atmospheric absorption coefficient (km^{-1})

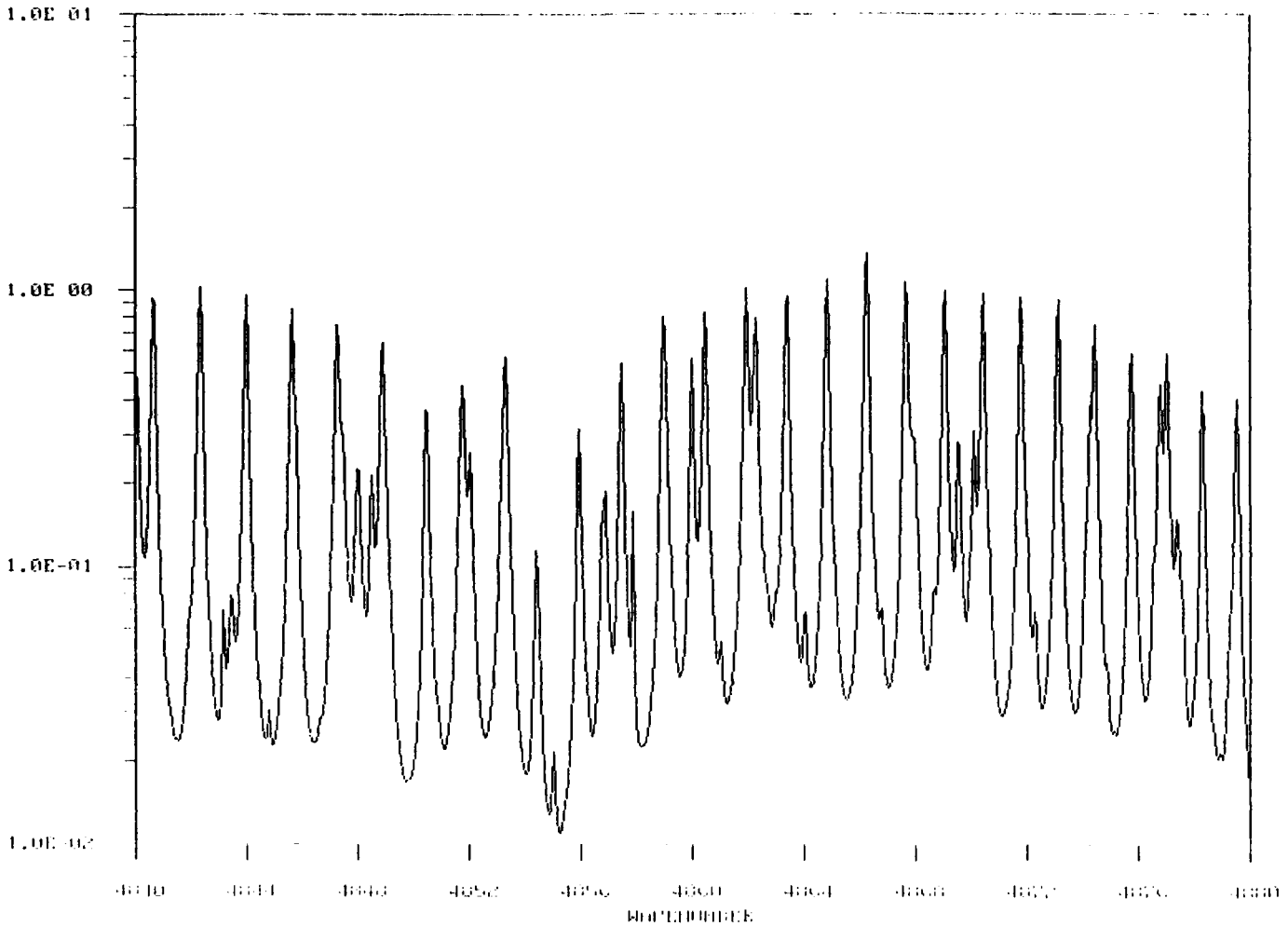

Fig. 74 — 4840-4880 cm^{-1} atmospheric absorption coefficient (km^{-1})

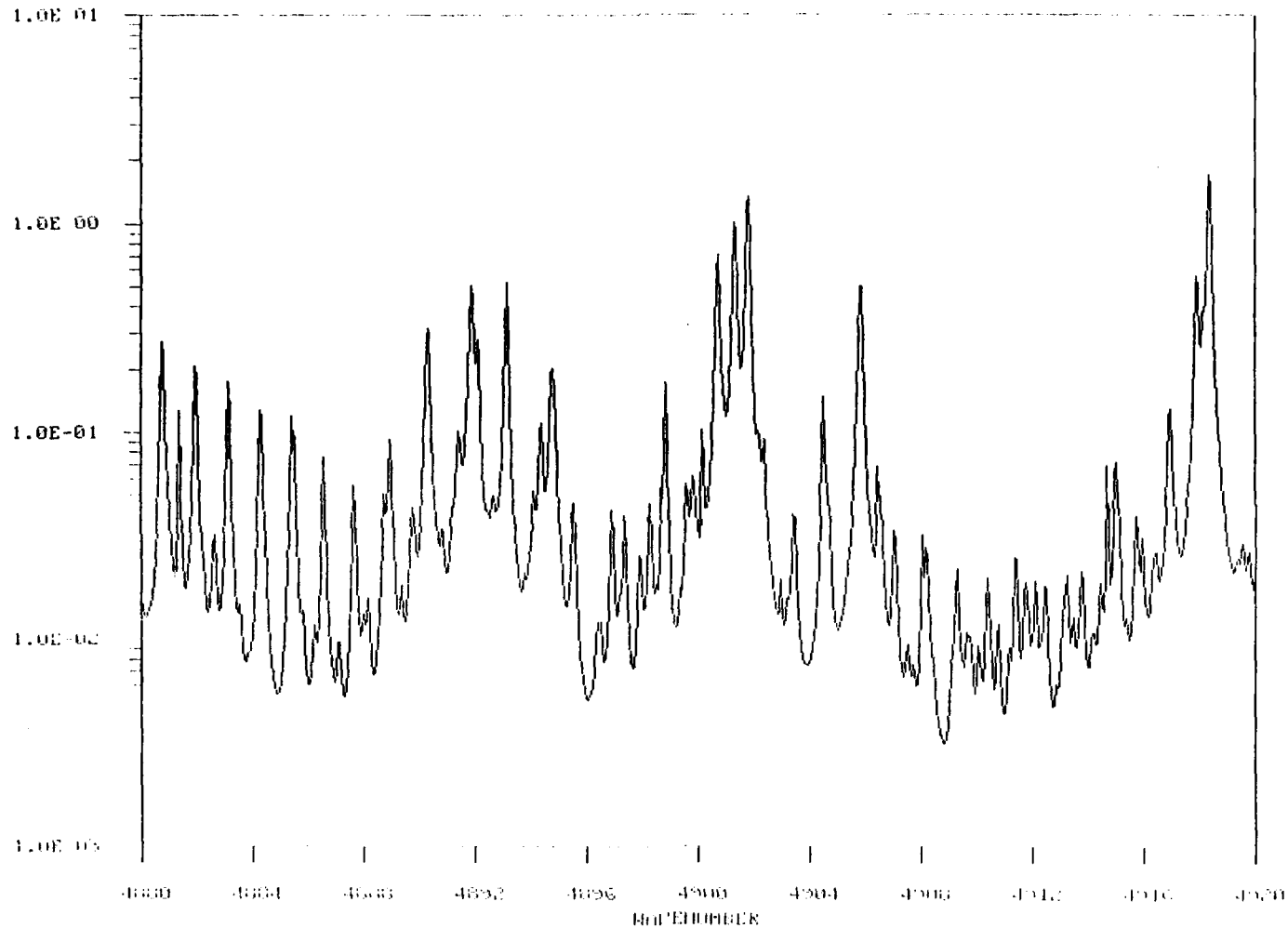

Fig. 75 — 4880-4920 cm^{-1} atmospheric absorption coefficient (km^{-1})

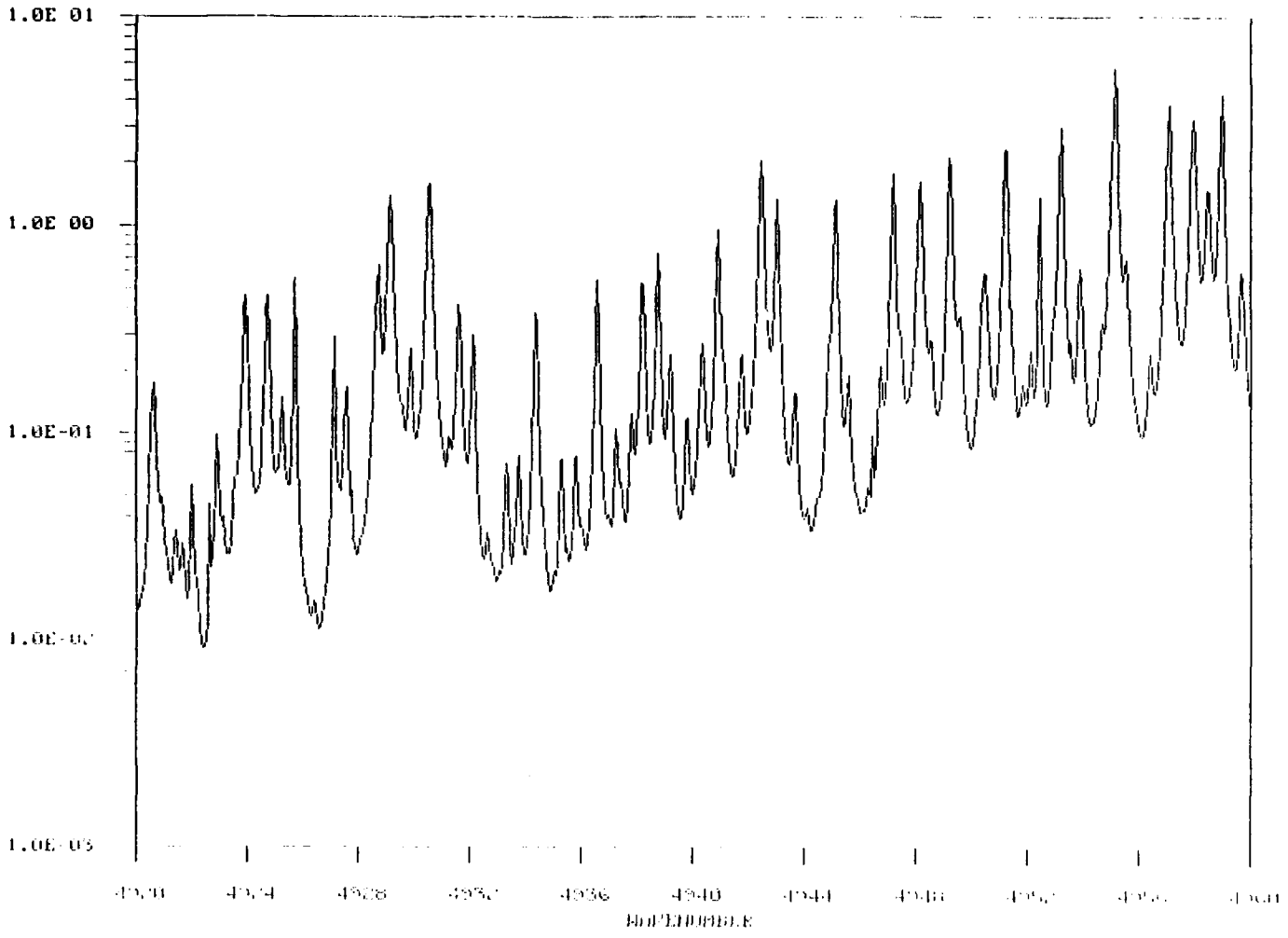

Fig. 76 — 4920-4960 cm^{-1} atmospheric absorption coefficient (km^{-1})

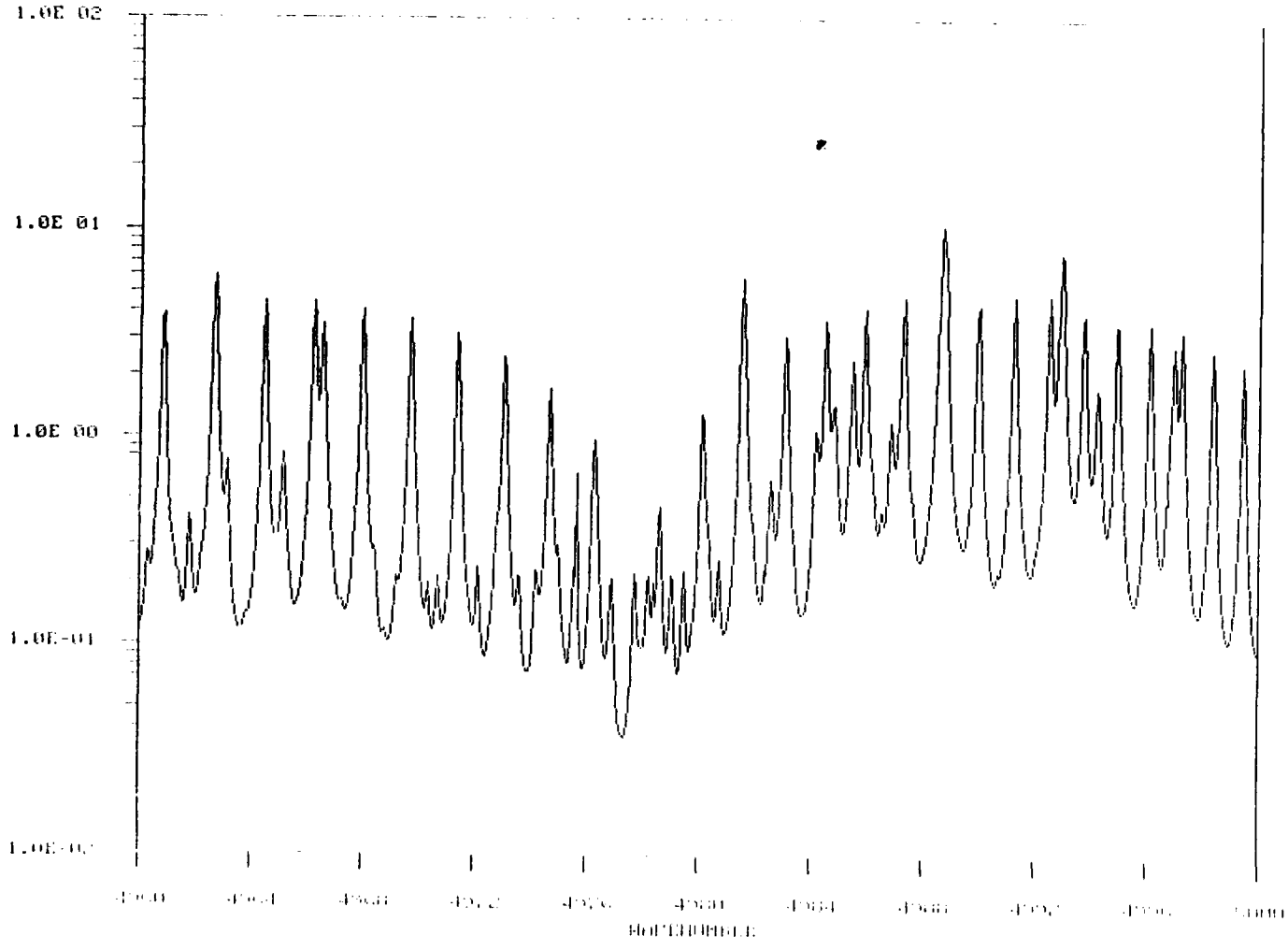

Fig. 77 — 4960-5000 cm^{-1} atmospheric absorption coefficient (km^{-1})

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